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MID-1980s DIGITAL AVIONICS INFORMATION SYSTEM CONCEPTUAL DESIGN CONFIGURATION

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GORDON A. ECKSTRAND, Director
Advanced Systems Division

Approved for publication.

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Commander

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The research reported herein is part of a larger research effort entitled "Digital Avionics Information System (DAIS) Life Cycle Costing (LCC) Study." The objective of the total effort is to provide USAF with an enhanced in-house capability to incorporate LCC considerations during all stages of the weapon systems acquisition process into the following trade-off areas: avionics design, weapon system operation and maintenance, and planning for manpower utilization and training. The initial application of the results of the study will be to assess the LCC impact of the implementation of the DAIS in the mid-1980s Close Air Support (CAS) weapon system.

The research reported in this technical report was performed to develop two conceptual design configurations. These demonstrate the application of the DAIS concept of avionics integration in the avionics suites of two CAS

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weapon systems: one of the present day genre, and one of the mid-1980s time frame. They will serve as the data baseline for the remaining tasks of the DAIS LCC Study.

This report presents the two conceptual design configurations representative of a current and a mid-1980s DAIS-configured CAS aircraft avionics suite. They are specified in detail sufficient to support the remaining tasks of the DAIS LCC Study, to include: maintenance task analyses; the development of realistic acquisition, operation, and support costs; and the development of suitable maintenance manpower training techniques and criteria.

The report describes in detail the six major subtasks conducted during the development of the conceptual design configurations: (a) the definition of functional requirements for the CAS mission; (b) the survey of avionics available for inclusion; (c) the generation of a current baseline avionics system; (d) the partitioning of the selected subsystems to effect a current DAIS conceptual design configuration; (e) the projection of technology to the 1980s era; and (f) the generation of a mid-1980s DAIS conceptual design configuration based upon the results of the technology projection.

SUMMARY

PROBLEM

The Digital Avionics Information System (DAIS) seeks to demonstrate a solution to the problem of proliferation and non-standardization of aircraft avionics. Since the DAIS concept of avionics integration has the potential to produce substantial cost benefits, it is important to assess the impact of operational implementation of the DAIS on the USAF operational and logistics support system in terms of Life Cycle Cost (LCC). To this end, a DAIS LCC Study was undertaken. The research covered by this technical report is the initial portion of that overall study effort. It furnishes the means to develop a data base for the eventual performance of an analysis of the potential impact of DAIS on weapon system acquisition, operation, and maintenance. The remainder of the study will address the development of that which the Air Force yet requires to perform the analysis. The fundamental objective of the DAIS LCC Study is to provide the Air Force with an enhanced in-house capability to incorporate LCC considerations, during all stages of the system acquisition process, into the following tradeoff areas: system design, system operation and maintenance, and planning for manpower utilization and training. The specific application of the resultant capability will be to evaluate the LCC of alternative design configurations for a DAIS-configured Close Air Support (CAS) aircraft. The objective of the research reported here was to develop conceptual design configurations which depict possible current and future representative applications of the DAIS approach to avionics integration. These will be subsequently used to develop the data required to perform the remaining tasks in the DAIS LCC Study and in the subsequent DAIS LCC impact analysis itself.

APPROACH

The approach to the development of both current and mid-1980s DAIS design configurations was structured in six major steps. These are outlined below. The analyses and decisions resulting from these six steps are detailed in the body of the report.

The initial step required a review of CAS mission requirements in order to determine the functional capabilities to be included in a CAS aircraft. This was accomplished through a review of both Air Force documents as well as contractor-generated documents that resulted from previous DAIS studies.

The second step necessitated a survey of available avionics. For each CAS function, the equipments being used on various Air Force and Navy aircraft for identical or similar purposes were identified and detailed technical descriptive data was gathered. The equipments being assembled for the DAIS integrated Test Bed were included in this survey. Information on the many equipments came from Government technical manuals and design specifications as well as manufacturers' documentation and verbal contacts with technical personnel at both Air Force Systems Program Offices (SPO) and manufacturers' engineering groups. This data was transformed into standardized technical description packages intended to be used as working documents throughout the DAIS LCC study with additional data (reliability, maintainability, and cost) incorporated at the appropriate downstream tasks. Using those equipments from the survey which are in 1975 operational inventory, a representative selection was integrated into a baseline, current, DAIS-configured CAS aircraft. To arrive at this baseline each of the selected subsystems was described to the subassembly level and then partitioned by functional purpose into either sensor, computer, or control/display areas. The latter two, in general, were then configured in terms of the appropriate DAIS core element definitions. Power supplies were identified, as appropriate, for eventual inclusion in a central DAIS power bus.

The next subtask required consideration of the advancement in technology expected to be operational around 1985. For this, the development trends in each of the major technology divisions was examined to determine either a technology's specific direction or its expected choices of direction. Next, the development time frame was considered to define 1985 availability in operational inventory.

The final subtask required a modification of equipments chosen for a CAS aircraft based on the prior technology projections and 1985 expectations. That selection was then appropriately partitioned and a representative mid-1980s DAIS-configured CAS avionics suite derived.

RESULTS AND CONCLUSIONS

Conceptual design configurations representative of a current and a Mid-1980s DAIS-configured CAS aircraft have been developed. They are specified in sufficient detail to allow the performance of maintenance task analyses, the development of realistic acquisition, operation and support costs, the development of suitable maintenance manpower training techniques and criteria. The avionics subsystems

were treated as modules. The resulting design configurations reflect this and are structured accordingly to facilitate the conduct of tradeoff analyses upon completion of the remaining portions of the DAIS LCC Study.

PREFACE

This technical report is the first of a series of reports under contract No. F33615-75-R-5218, "DAIS Life Cycle Costing Study" which, in combination with present Air Force capabilities, will provide the means to assess the life cycle cost (LCC) impact of operational implementation of the Digital Avionics Information System (DAIS).

The study was directed by the Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio. It was performed under Air Force Avionics Laboratory Program Element 63243F, "Digital Avionics Information System", Project 2051. Project 2051, "Impact of DAIS on Life Cycle Costs", is jointly sponsored by the Air Force Human Resources Laboratory, Air Force Avionics Laboratory, and Air Force Logistics Command. Contract funds were provided by the Air Force Avionics Laboratory. The DAIS Program Manager was Maj. John G. Weber. The DAIS Chief Engineer was Mr. Frank Scarpino. The Air Force Human Resources Laboratory Project Scientist was Maj. Duncan L. Dieterly. The Air Force Logistics Command Project Officer was Mr. Ron Greene. The latter two are DAIS Deputy Directors.

This research effort is documented under Work Unit 20510001, "DAIS Life Cycle Costing Study". Mr. H. Anthony Baran was the Work Unit Scientist and Air Force Contract Monitor. The contractor Program Manager was Mr. Herbert E. Engel.

The authors wish to extend their appreciation to the many people within the Government and private industry who contributed their time and expertise throughout the course of this research. Too numerous to mention by name, it must be sufficient to note that considerable assistance was rendered by: The DAIS engineering staff, personnel at the San Antonio and Oklahoma City Air Logistics Centers, Air Force Logistics Command Headquarters, Aeronautical Systems Division, various organizations within the U.S. Navy, and numerous companies within private industry.

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1. INTRODUCTION

BACKGROUND

The designer of military avionics systems has been confronted with an extremely difficult task in recent years. Rapid advances in technology have placed an increasing premium on both capability and flexibility. Simultaneously, cost pressures from increased system complexity, higher maintenance expense, and general economic inflation have forced the designer to address the total cost of ownership in avionic systems. Historically, the mission information requirements have been established along essentially autonomous subsystem areas. Human resources and training requirements were often considered after the fact. The result was a proliferation of non-standard avionics equipment, and a design process that failed to minimize Life Cycle Cost (LCC).

THE DIGITAL AVIONICS INFORMATION SYSTEM

The Digital Avionics Information System (DAIS) seeks to demonstrate a solution to the problem of proliferation and non-standardization of aircraft avionics. The DAIS concept has the potential of bringing substantial benefits to system reliability and cost because it gives: (1) an ability to modify software to meet new requirements, (2) the potential for improved reliability through the planned use of redundancy at subsystem, equipment, and component levels, (3) opportunity for adding new sensors and capabilities to the system without rewiring the aircraft, and (4) an effective means for using modular or common equipment design on different types of aircraft.

To capitalize on this potential the U.S. Air Force (USAF) established in July 1973 a DAIS Advanced Development Program (DAIS ADP). The Air Force Avionics Laboratory (AFAL) is the lead agency and is coordinating the efforts of AFAL, the Aeronautical Systems Division, the Aerospace Medical Research Laboratory, the Air Force Flight Dynamics Laboratory, the Air Force Atlantic Test Center, Rome Air Development Center, the Air Force Logistics Command, and the Air Force Human Resources Laboratory. Their objectives are to demonstrate the DAIS concept on a functional basis and to develop: (1) an in-house cadre of skilled personnel who can perform preliminary design and prepare specifications; and

(2) standards and techniques for the four common or core elements of all avionics systems, namely, multiplex, processors, control and displays, and software. To advance the time and degree of DAIS concept implementation, a DAIS Integrated Test Bed and Software Test Stand have been planned.

The configuration selected by AFAL for development consists of several identical processors communicating with one another and the other items of the system via a time-division multiplex line in a so-called federated configuration. Individual Line Replaceable Units (LRU) called Bus Control Interface Units connect the processors to the multiplex line. Individual LRUs called Remote Terminal Units connect the sensors to the multiplex bus. The multiplex lines, the Bus Control Interface Units, and the Remote Terminal Units constitute the multiplex core element. A group of units such as displays, keyboards, etc., constitute the Controls and Displays core element. The programs of the software core element are loaded into the individual processors via the on-board storage unit.

The DAIS effort recognizes that the software element plays a key integrating role with a significant potential impact on life cycle costs. Current Air Force software expenditures exceed computer hardware expenditures and have, therefore, supplied one of the motivations for the development of the DAIS system.

DAIS Mission Software uses a higher order language (JOVIAL) which will have a beneficial cost-effective impact on development and maintenance of the software. A highly modular architecture is used so that minimal reprogramming results from any mission-to-mission reconfiguring. Furthermore, these software modules can be changed as readily as the hardware with its plug-in/plug-out design concept.

THE DAIS LIFE CYCLE COST MODELING SYSTEM

LCC analysis is a significant element in the DAIS program. Recognition of its importance led to a previous LCC Analysis effort [19] performed by the ARINC Research Corporation in which an initial estimate was made of relative costs and cost savings provided by DAIS.

Historically, the life cycle of a system has been viewed as being comprised of a series of distinct phases of activity. These phases were defined in relation to distinct changes in the patterns of activity engaged in by people associated with the system. Each phase (Conceptual, Development, Acquisition, Operation and Maintenance, and Salvage) was regarded as distinct and almost mutually exclusive and capable of being dealt with independently. Unfortunately, the original reasons

for establishing such a structure (acquisition management, funding allocation, cost accounting, etc.) have in recent years changed in emphasis. New driving factors such as manpower availability, training requirements, and severe budgetary constraints strongly indicate the need for determining the interrelationship of factors both within and across these phases. Today the systems planner needs the ability to determine what effect changing a factor within one phase will have on other phases, as well as the effects of changing a factor within a phase.

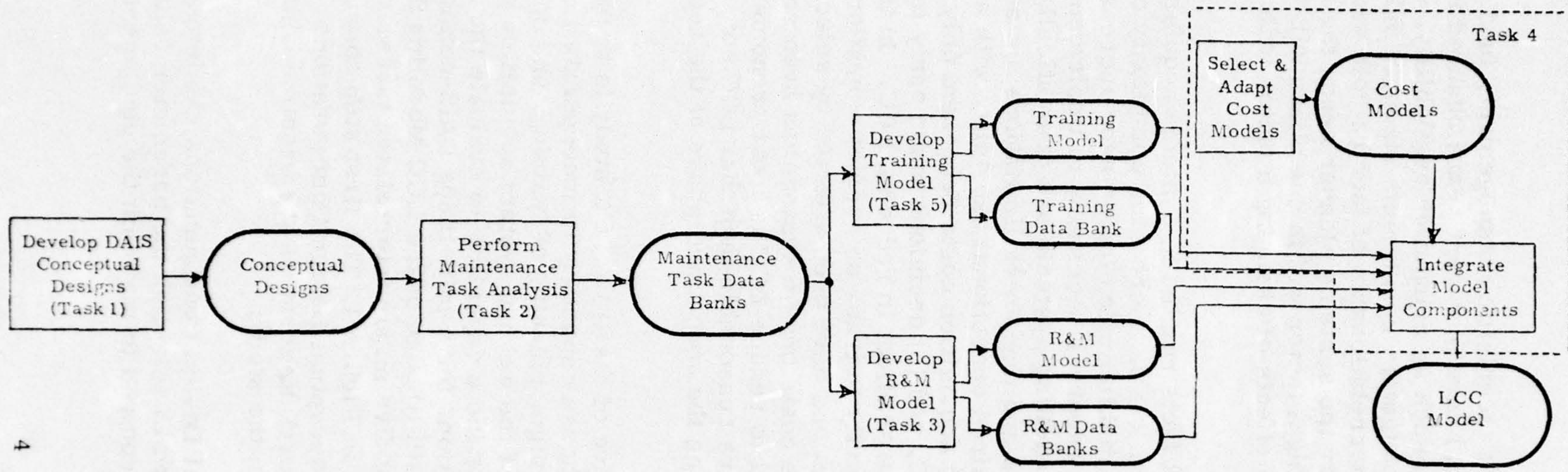
Over the years, several facts related to systems acquisition have become increasingly clear: (1) the increasing complexity of mission requirements has resulted in a need for an ever-increasing use of new technology, (2) the resources necessary to implement new technology and to support the resulting systems are dramatically increasing, (3) budget constraints and manpower limitations dictate a critical need for obtaining required operational capability with minimum resource expenditure, (4) acquisition costs represent only a portion of the total system LCC, and (5) decisions made early in the conceptual phase have the greatest effect in reducing LCC. In the past, LCC has been used primarily to track or predict operation and maintenance costs. Cost reductions have been effected by selecting logistic actions which minimize costs once a system has been acquired. However, the potential to reduce LCC is most pronounced in the conceptual phase. It appears reasonable then that LCC considerations should be introduced during the conceptual phase of the acquisition process.

The fundamental objective of the DAIS LCC study is to provide the USAF with an enhanced in-house capability to incorporate LCC considerations into avionics design, planning of training, and operation and maintenance at all stages of the weapon system acquisition process. In particular, it will provide a capability to evaluate the LCC of alternative design configurations for a mid-1980s DAIS-configured Close Air Support (CAS) aircraft. Design of the LCC Modeling System has been structured in terms of five major interrelated tasks. An overview of the study is shown in Figure 1. The first step consisted of developing representative Conceptual Design Configurations (described in detail in this report) to serve as the baseline configurations for the remaining tasks in the study.

Based on the Conceptual Design Configurations, Maintenance Task Analyses will be conducted to establish the parameter values that describe the individual tasks required to maintain the equipment com-

Figure 1

DAIS LCC STUDY TASKS



prising the designs. Reliability data will also be developed. The results of these efforts will be in the form of computerized data banks.

The Reliability and Maintainability (R&M) Model assists the user in introducing perturbations from the nominal values to conduct sensitivity analyses. Functional relationships between characteristics of the equipment design, manpower capabilities, the logistics system, and consequent R&M will provide a vehicle for influencing design during the conceptual phase of the acquisition process.

The operations and support (O&S) portion of LCC is computed through an adaptation of an existing Logistics Support Cost (LSC) Model. The equations defining O&S cost elements are modified to account for the configuration and new capabilities associated with DAIS.

The Maintenance Task Analysis also serves as a forcing function on the development of the DAIS Training Model since the former specifies the skill requirements. The DAIS Training Model will allow the investigation of alternative methods of achieving the required skills (formal training vs. on-the-job training (OJT), different media and training aids, etc.). Costs associated with these different alternatives are among the inputs to the Training Data Bank.

Acquisition costs for both the current and mid-1980s design are established through projections provided by appropriate cost estimating relationships (CER). The overall LCC Model is generated through the integration of models and data banks designed to provide the appropriate cost components for the system LCC. The resulting modular modeling system and associated data banks will be compatible with the Air Force Human Resources Laboratory (AFHRL) Maintenance Manpower Modeling System (MMMS) which calculates resources consumed during simulated maintenance operations under specified conditions.

Since data banks related to the DAIS Conceptual Design Configurations will be provided, they will be used in conjunction with the LCC Modeling System to develop LCC and training requirements. The LCC modeling system is modular and its design is general enough that other aircraft subsystems may be investigated as well. Thus, it can serve as a vehicle for the study of alternatives in the area of design, training, and maintenance concepts for other system applications as well as DAIS.

CONCEPTUAL DESIGN CONFIGURATION STUDY

The Conceptual Design Configuration Study has been structured in six major steps. The details are provided in Sections 2 through 5 of this report. An overview of the study and the relationship of these efforts is shown in Figure 2. The starting point for the effort was the CAS Mission Requirements. These were available from Air Force sources as well as from previous relevant work that had been done on the DAIS program. The CAS mission requirements define the types of targets encountered and types of weapons to be used. By means of a functional analysis, these requirements are translated into the functional needs to be satisfied by the aircraft avionics. These include navigation, communications, countermeasures, air-ground attack, control & display.

The next step was to survey the current military avionics inventory in order to develop a baseline design. Since the F-15, A-10 and the A-7D avionics are functionally related to those of a CAS aircraft, they were considered first. To complete the total matrix of candidate equipments that meet the functional requirements for the CAS avionics suite other aircraft were studied; i.e., F-14, F-111, and A-7E.

Through applications of appropriate selection criteria to the total matrix of candidate equipments, a set of subsystems was selected as the most appropriate for the current DAIS Conceptual Design Configuration. This set was then partitioned into sensor and core element sections based on the functions provided by the component subassemblies comprising each LRU. The resulting product is a conceptual design configuration representative of current technology but configured into sensor and core element sections in accordance with the DAIS concept.

To develop the Mid-1980s DAIS Conceptual Design Configuration, a technology projection was made so that new equipments and technology available in that time period could be incorporated. Each sensor and core element area was studied separately to identify the likely technology advances. A realistic estimate of what might exist as a DAIS design in the Mid-1980s was then generated by combining equipment that can be expected to undergo technological change with that which is expected to remain the same during the time period in question. These were then partitioned into sensor and core elements to generate the Mid-1980s DAIS Conceptual Design Configuration.

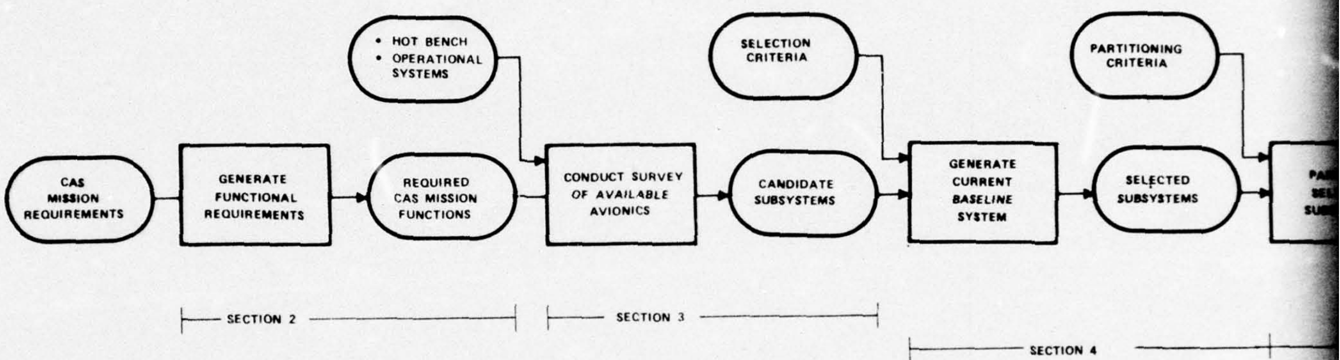
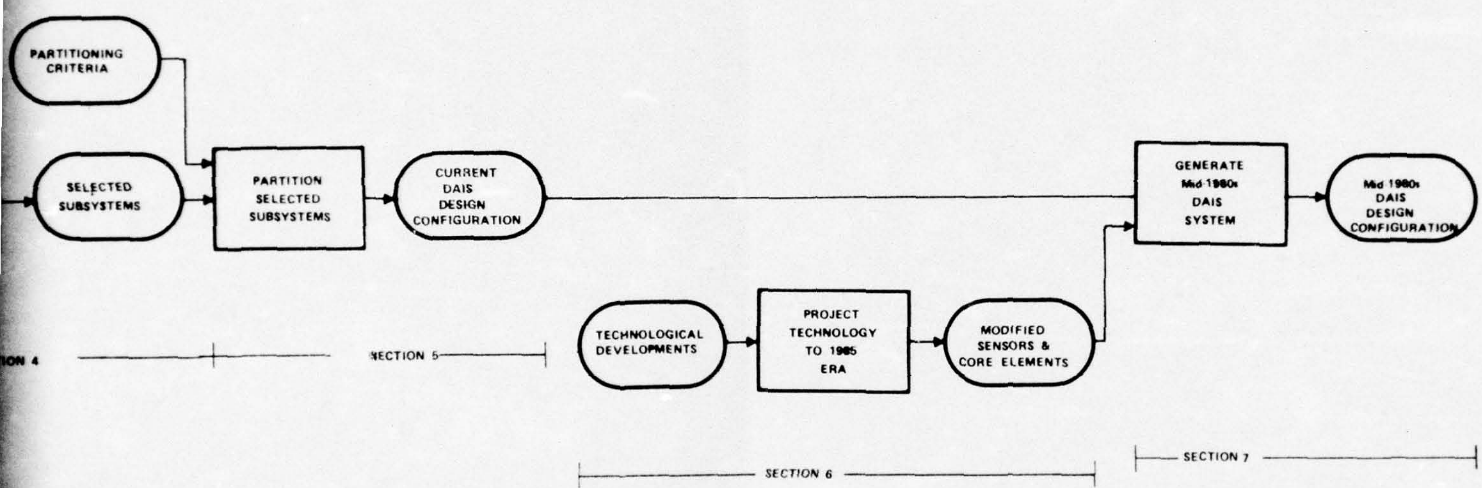


FIGURE 2 DEVELOPMENT OF DAIS CONCEPTUAL DESIGN CONFIGURATION



PTUAL DESIGN CONFIGURATION

2

The DAIS Conceptual Design Configurations described in detail in the following sections are representative of the avionics suites for both current and 1980s DAIS-configured aircraft. The current configuration is representative of the technology in the present day inventory, while the mid-1980s configuration incorporates advanced technology projections. These configurations will later be used as the basis for LCC comparisons. They will serve as vehicles for conducting meaningful maintenance task analyses for adapting R&M, training, and LCC models to achieve the overall objectives of the DAIS LCC Study.

II. FUNCTIONAL REQUIREMENTS

INTRODUCTION

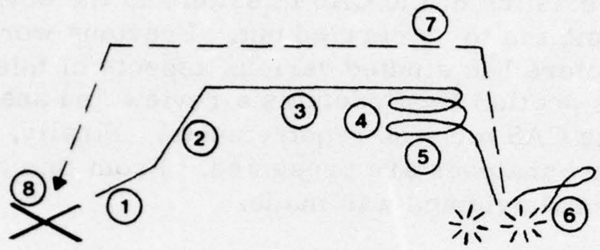
The types, quantity, and capability of the required avionics derive from the characteristics of the CAS mission and the environment in which that mission is to be carried out. Previous work by the USAF as well as contractors has studied various aspects of this mission scenario. This section first contains a review and analysis of this work to define the CAS mission requirements. Finally, the results of the engineering analyses are presented. From this analysis a selection of functional avionics was made.

TYPES OF MISSIONS

Three types of missions have been identified for the current CAS aircraft. Of these, the primary mission is to support the operations of friendly ground forces by attacking enemy troops and ground equipment. The latter may involve enemy lines of communication and transportation, material, air capability on the ground (aircraft as well as hangars and runways), and ground counter-air activities in the form of anti-aircraft batteries, surface-to-air missiles, radars, etc.

The mission is normally conducted under the control of a forward air controller (FAC) who has been located in the vicinity of the forward edge of the battle area. The FAC designates the targets to be attacked. He will also specify the tactics and timing to be used in the attack. A mission profile characteristic of this mission is shown in Figure 3. Depending on the battle situation, the aircraft may be required to fly up to 5 or 6 sorties of this type in a single day.

A second type of mission is the pre-planned attack against heavily defended targets. While not capable of carrying out a long range interdiction mission, the CAS aircraft is required to carry out short range interdiction missions against enemy material and communication lines up to 100 miles inside enemy territory. Other requirements of this mission are that the aircraft be capable of destroying enemy air capability on the ground as well as the destruction or neutralization of the sensors and weapons involved in counter air activities. A typical profile for this type of mission is shown in Figure 4.

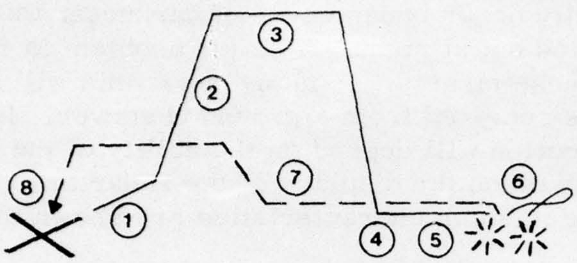


PURPOSE

DESTROY DESIGNATED TARGETS IN IMMEDIATE SUPPORT OF GROUND FORCE OPERATIONS

MISSION SEGMENT	PRIMARY MISSION FUNCTIONS
1	SCRAMBLE TAKEOFF
2	CLIMB
3	CRUISE TO DESIGNATED AREA (FEBA)
4	LOITER ON STATION
	- COORDINATE WITH FORWARD AIR CONTROLLER (FAC)
5	DETECT AND IDENTIFY TARGETS
6	DELIVER WEAPONS (GUNS, BOMBS, AIR/GROUND MISSILES)
	- MULTIPLE PASSES, IF REQUIRED
7	RECOVER TO BASE
8	RELOAD, REFUEL, TAKEOFF ON NEXT SORTIE

FIGURE 3 CLOSE AIR SUPPORT OF FRIENDLY GROUND FORCES



PURPOSE

INTERDICTION - DESTROY DESIGNATED ENEMY MATERIAL AND DISRUPT LINES OF COMMUNICATION

COUNTER AIR - DESTORY ENEMY AIR CAPABILITY ON THE GROUND

DEFENSE SUPPRESSION - DESTROY OR NEUTRALIZE GROUND COUNTER AIR ACTIVITIES

MISSION SEGMENT	PRIMARY MISSION FUNCTIONS
1	PRE-FLIGHT AND TAKEOFF
2	CLIMB AND ACCELERATE
3	CRUISE TO DESIGNATED AREA
4	PENETRATE ENEMY TERRITORY - PRIMARY MODE: LOW ALTITUDE PENETRATION - ALTERNATE MODE: HIGH ALTITUDE PENETRATION - HEAVY ENEMY DEFENSES: FLY AT HIGH SPEED, USE ECM
5	DETECT AND IDENTIFY TARGETS
6	DELIVER WEAPONS - PRIMARILY A SINGLE PASS ATTACK, BUT MULTIPLE PASSES CAN BE USED, IF NECESSARY
7	RECOVER TO BASE
8	POST FLIGHT

FIGURE 4 PRE-PLANNED ATTACK AGAINST HEAVILY DEFENDED TARGETS

The third mission type required of the CAS aircraft is that of a quick reaction attack against short life targets and targets of opportunity. Typical targets associated with this type of mission are mobile artillery and troops moving along trails or crossing rivers. Because such troop movements typically occur under cover of darkness, this type of mission is often carried out at night. A major problem is the detection and acquisition of these targets. In many cases this will be enhanced by verbal directions received from a ground observer. In general, however, target detection will depend on the ability of the pilot to see the target directly or on the displays of the radar or electro-optical sensors. The mission characteristics are shown in Figure 5.

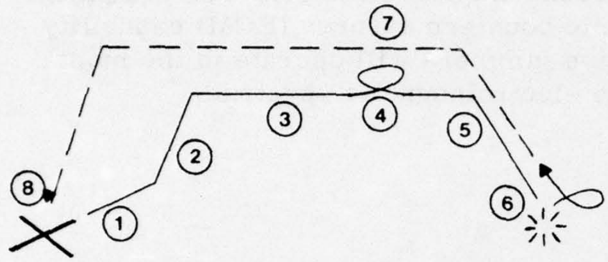
The weapons complement for the CAS airplane will include a gun, conventional munitions, electro-optical and laser guided weapons, and infrared homing air-to-air missiles. The types and quantities of weapons will vary from sortie to sortie depending on the specific mission objectives. A typical CAS airplane will be capable of carrying up to 16,000 pounds of fixed ordnance using both internal and external carriage.

THE MISSION ENVIRONMENT

The CAS airplane may be required to operate anywhere in the world, as needed, to support the operations of our ground forces or those of our allies. During wartime, it will often be required to operate out of forward austere air bases. In many cases, these forward bases will have short (less than 5,000 feet) unimproved runways, a minimum of logistics, maintenance support facilities, and ground based landing aids. During peak activities, the CAS airplane will be required to fly up to 5 or 6 sorties per day.

Often ground force operations take advantage of darkness and bad weather to conceal troop and equipment movements. Thus, the CAS aircraft will require an all-weather, day/night ability to perform its mission.

The active enemy defenses may include a variety of anti aircraft artillary (AAA) and surface-to-air missiles (SAM) such as the SA-2, SA-3, and SA-6. The CAS aircraft can anticipate encountering high performance enemy interceptor aircraft with guns and air/air missiles. When flying at low altitudes, it may be subjected to concentrated small arms fire and shoulder-launched rockets. Another possible threat in the mid-1980s era is that of laser weapons.



PURPOSE

DESTROY SHORT LIFE GROUND TARGETS OR TARGETS OF OPPORTUNITY

MISSION SEGMENT	PRIMARY MISSION FUNCTIONS
1	SCRAMBLE TAKEOFF
2	CLIMB
3	CRUISE TO OPERATIONAL AREA - NEAR OR BEHIND FEBA
4	AIRBORNE ALERT LOITER, IF REQUIRED
	- COORDINATE WITH FAC OR OTHER OBSERVER UNIT
5	DETECT, ACQUIRE, AND IDENTIFY TARGET
	- DAY/NIGHT ALL WEATHER CAPABILITY IS REQUIRED
6	DELIVER WEAPONS
7	RECOVER TO BASE
8	POST FLIGHT

FIGURE 5 QUICK REACTION ATTACK AGAINST SHORT LIFE TARGETS

Radars which provide the enemy with a detection and tracking capability will include long range detection radars, AAA direction radars, SAM director radars, and ground-controlled intercept (GCI) radars.

Using either or both ground-installed and airborne equipment the enemy will use an electronic countermeasures (ECM) capability against the CAS aircraft. Active jammers will operate in the most commonly used portions of the electromagnetic spectrum.

REQUIRED CAS FUNCTIONS

In this section we discuss the requirements and the rational for selecting or excluding specific types of implementations associated with the major avionic functions of navigation, communication, countermeasures, air-ground attack, controls and displays, electrical power management, and central integrated test.

Navigation

The navigation function requires the computation of the basic navigational parameters; i.e., position, heading, and velocity. These are provided for display to the aircrew and are also outputted to other subsystems for reference use in other computations.

Accurate position data is required for initial target acquisition, for bombing on coordinates, as well as bombing following a period of blind navigation. Accurate weapon delivery also requires velocity of the order of one to two feet per second.

A conventional four-gimbal all-attitude inertial system using a true airspeed velocity reference has been chosen as the primary source of navigation. Currently available systems of this type provide accuracies better than one-half mile per hour, circular error probability (CEP). They are also totally insensitive to enemy electronic countermeasure (ECM).

Since one of the CAS mission types involves fast reactions against short life targets, occasions will arise when scramble take-offs will be required with little time available for alignment. It is imperative, therefore, that the navigation alignment modes provide (a) inflight align, (b) rapid ground align to a stored heading, as well as (c) the normal gyrocompassing alignment mode.

In the event of failure of the primary inertial system, true airspeed dead reckoning will be required. In the dead reckoning mode, a heading attitude reference system (HARS) will be required. This function is provided as a normal submode in most inertial navigation systems.

The CAS aircraft will require an air data system consisting of pressure and temperature sensors, conversion electronics, and central air data computations. The central air data computations provide for outputting air data quantities such as Mach number, pressure density, angle of attack, and true and indicated airspeeds.

Navigation within the Air Traffic Control System of the US as well as other International Civil Aviation Organization (ICAO) countries will require various radio navigation aids. These will include tactical air navigation (TACAN), ultra high frequency - automatic direction finder (UHF-ADF), and a beacon transponder. Localizer and glide slope deviation and steering command signals will be computed in an instrument landing system (ILS). Radar altimeter will be required for letdowns in bad weather, calibration of system altitude, and as an altitude source for bombing.

Selection Rationale

The primary subsystem selected for the navigation functions was the inertial measurement set (IMS). This subsystem was selected because it is the one avionics subsystem that can accurately supply outputs to perform the largest number of the required CAS mission functions during all conditions (day/night, fair/adverse weather), while operating totally self-contained (does not radiate and cannot be jammed). In addition, it has backup mode outputs of attitude and heading for partial use as a navigator in the event of a primary IMS failure.

A second navigation subsystem is the air data computer (ADC) which is included for several reasons. It is the only accurate means of providing any altitude information at altitudes of 5,000 feet or more above the terrain. It is a primary source of airspeed which, when combined with inserted wind speed and direction and used in conjunction with the attitude and heading mode of the IMS, can function as a backup source of resolved velocity for updating present position computations. The ADC is also an accurate source of air-stabilized aircraft data such as Mach number, angle of attack, and impact pressure necessary for weapon delivery and limiting functions (i.e., rudder and stabilizer limits) for the flight control system.

A radar altimeter was included to provide an accurate source of altitude above the terrain (to a maximum of 5,000 feet) during bad weather approaches for landing or for terrain following during bombing runs. As a further aid in landing during foul weather conditions, an instrument landing system (ILS) was included to provide localizer and glide slope deviation as well as steering commands.

To extend the range of friendly interrogating (shipboard or landbased) radar sets, and thus facilitate the location of the CAS aircraft position relative to the point of interrogation, a radar beacon was included. This beacon will function in both coded and uncoded modes.

The basic navigation functions described above will be supplemented and enhanced by inputs from TACAN and UHF-ADF systems. The UHF transceiver is the primary line-of-sight communcation link for the Air Force and when coupled with an ADF antenna provides bearing information to selected UHF transmitters. A TACAN system enables the CAS aircraft to obtain bearing and distance information to shipboard and landbased (portable or permanent) TACAN stations.

Exclusion Rationale

In arriving at the above complement of CAS navigation system functions, numerous others were considered and eliminated. The following is a brief explanation of the reasons for these decisions.

Navigation satellite systems and the OMEGA System were eliminated because their state of development, with respect to the evolution of production airborne units, places them in a status which could not be considered operational for a current CAS aircraft.

Long range navigation (LORAN) was eliminated due to the relative applicability and processing load where TACAN and UHF-ADF remain to provide alternate means of long range navigation and a laser target seeker is available for precision navigation to designated targets.

Doppler radar was omitted because current inertial measurement systems (IMS) are sufficiently accurate to fulfill the primary navigation requirements without Doppler damping. They can also supply accurate attitude information. An additional consideration was that backup navigation can be accomplished using the ADC.

A heading and attitude reference system (HARS) was eliminated in favor of an IMS with a HARS backup mode capability, in the interest of saving weight, space, and electronic hardware.

Communication

The communication system's principal function is to provide coordination and information transfer between the aircraft and other operating units. This information transfer may be air-to-air communication between aircraft or air-to-ground and ground-to-air communication between own aircraft and home base, operational control centers and other ground stations for tactical coordination. The primary purpose of these communications with the CAS aircraft is to permit central control of tactical forces and weapons in near real-time for any tactical situation. The near real-time nature of the communications enables the controller to appraise the tactical situation, make timely operational decisions, evaluate the effect of actual operations, evaluate the probable effect of proposed operations, develop new operational plans, and disseminate timely decisions.

The information to accomplish these functions will be transmitted either by voice in a normal or secure mode or by digital data transfer in a normal or coded format.

Selection Rationale

To fulfill the above functions and transmit/receive in each of the required frequencies and formats, several types of communication systems are required. The Air Force and Navy both use the UHF transceiver as their primary line-of-sight communications link. Therefore, a UHF system was selected for the current DAIS CAS aircraft to be used for air-to-air voice communication, data link, relay link, and air-to-ground voice communication with control centers.

A high frequency (HF) radio was selected for the long-range (up to 5,000 miles), over-the-horizon communication. It allows for both air-to-air and air-to-ground voice communication.

The Army normally uses the frequency modulation (FM) band for their communication and, therefore, the CAS aircraft has a very high frequency/frequency modulation (VHF/FM) radio transceiver for line-of-sight communication with ground troops and forward air controllers.

An identification friend or foe (IFF) system was included to enable identification by friendly airborne, shipboard or ground based IFF/Air Traffic Control Stations. To accomplish this function, it receives coded interrogation signals which it detects, decodes, and then responds by automatically transmitting a coded reply.

As indicated above, the CAS aircraft spends a good portion of its time operating in or near enemy territory. For this reason, and to allow adequate information transmission without undue divulgence of combat tactics, a secure voice communication system was included.

A data link system was selected to automatically communicate information and data which would be awkward or impossible to transfer through voice communication. Examples of such information the data link system might be used to transmit include position, aircraft, status, weapon guidance, and sensor data.

To facilitate communication with the ground crew while the aircraft is on the ground, and to function as an interconnection control device between the headset and various radio receivers, an intercommunication set (ICS) was included in the avionics complement.

Exclusion Rationale

Of the communication systems considered in Table 1, one general type was excluded from the CAS aircraft complement: the very high frequency/amplitude modulation (VHF/AM) radio transceiver. Its basic function is line-of-sight communication for air-to-air and air-to-ground voice modes. Although this frequency range is often used for civilian air traffic control and commercial aviation, other systems already included for more direct purposes also adequately fulfill these functions. It is noted that the A-7D does not contain a VHF/AM radio.

Countermeasures

The electronic countermeasures (ECM) equipment is designed to detect enemy transmissions, analyze the received signals, and provide both warning to the pilot and protection, by deceiving the enemy radar and other tracking devices.

The CAS aircraft, being exposed frequently to the hostile environment, must carry a complete complement of countermeasures equipment for self protection.

Selection Rationale

A radar homing and warning (RHAW) system is selected for the CAS aircraft to detect incoming radar signals and analyze their video content for signal strength, repetition frequency, and antenna scan rate characteristics. After analysis, the RHAW provides a visual indication of the threat type and an aural alert.

To protect the aircraft while being tracked, an ECM pod is installed to inhibit the performance of the enemy air defense system by degrading the defensive system sensors' performance. The ECM pod provides this increased aircraft survivability when penetrating hostile territory by jamming, which is intended to destroy the ability of hostile sensors to determine true aircraft range and angle.

Also selected as countermeasures equipment for the CAS aircraft was an infrared (IR) tail warning system. Its basic functions are identical to those of the RHAW except that it detects and warns when the aircraft is being tracked by an IR seeker as opposed to radar. Upon receipt of this warning, the pilot initiates a tactic which creates range and angle confusion by deploying expendables. To accomplish this, a chaff and IR flare system was included. Its basic function is to deploy chaff, flares, miniature jammers, and decoys in selected sequences and trajectories.

Exclusion Rationale

In much of the countermeasures equipment surveyed, many of the same functions are accomplished by equipments which have different names. Thus, several of the equipments listed in Table 1 have been eliminated without the elimination of their functions since they are performed by the selected equipments discussed above. Equipments which were eliminated by this means include the RF jammer, the radar warning, the electronic warfare warning system (EWWS), the RF blanker, and the ECM destruct.

Table 1 AVIONICS EQUIPMENTS LISTING

Subsystem	Nomenclature	Aircraft Applications*	
NAVIGATION			
HARS	ASN-108	F-15A	
	ASN-129	A-10A	
INS	ASN-90**	A-7D	
	ASN-92	----	(A-6/F-14)
	ASN-109	F-15A	
UHF/ADF	ARA-50**	A-7D	(A-4)
	OA-8639/ARD	F-15A	
	ARR-69**	A-7D	(F-4/A-4)
TACAN	ARN-52**	A-7D	(A-4)
	RT-1045/ARN	F-15A	
	ARN-84	A-10A	(A-4/A-7/ F-14)
	ARN-118	A-10A	
ILS	ARN-58**	A-7D	
	R-1755/ARN	F-15A	
	ARN-108	A-10A	
LORAN	ARN-92	A-7D	
Doppler Radar	APN-153	----	(A-4)
	APN-185	----	(F-111)
	APN-189	----	
	APN-190**	A-7D	
ADC	CP-953A/AJQ	A-7D	
	ASK-6	F-15A	
Radar Beacon	APN-154**	A-7D	(A-4)
	UPJ-25	A-10A	
Radar Altimeter	APN-141**	A-7D	(A-4)
	APN-194	A-7E/F-14A	
COMMUNICATION			
UHF	ARC-51**	A-7D	
	ARC-109	F-15A	(A-4)
	ARC-164	A-10A	
HF	ARC-123**		(F-111)
	ARC-154	A-10A	

Table 1 (continued)

Subsystem	Nomenclature	Aircraft Applications*	
VHF-FM	FM-622A**	A-7D/A-10A	
	ARC-114	----	(A-4)
VHF-AM	ARC-115	----	(A-4)
Secure Radio	TSEC/KY-28	A-7D/F-15A	
Intercom	AIC-18	A-10A	(F-5)
	AIC-25	----	(F-111)
	AIC-26**	A-7D	
Data Link	ASW-25A	A-7E	
IFF	APX-72	A-7D	(A-4)
	APX-76	F-15A	
	APX-101	A-10A	
COUNTERMEASURES			
RHAW	APR-36/37	A-7D	
	ALR-46	A-7D	(F-4/ F-105)
IR Tail Warning	AAQ	A-10A	
ECM Pod	ALQ-71	A-7D	(A-4/F-4/ F-101)
	ALQ-72	A-7D	(A-4/F-4/ F-101)
	ALQ-119	A-7D	(F-4/F-16/ F-111)
Chaff & IR Flares	ALE-37	A-10A	
	ALE-38	A-10A	
	ALE-39	A-10A	(A-4/A-6/ F-4/F-14)
	ALE-40	A-10A	(F-4/F-16)
RF Jammer	ALQ-135	F-15A	
IR Jammer	ALQ-140	----	(F-4)
Radar Warning	ALR-56	F-15A	
RF Blanker	MX-8252/A	A-7D	
	MX-9287/A	F-15A	
ECM Destruct	MX-8261/ASQ	A-7D	
EWWS	ALQ-128	F-15A	

Table 1 (continued)

Subsystem	Nomenclature	Aircraft Applications*
AIR-GROUND ATTACK		
ILLLTV		
LTS	AAS-35	A-7D
FLIR	AAS-28A	A-7D (test) (RF-4)
FLR	APQ-126** APQ-153 APQ-( )	A-7D (F-5) F-16A
Camera	KB-18A KB-27A	A-7D F-15A
Missile Launcher	LAU-88/A	A-10A
Missile	AGM-65A	A-10A
GAU-8A Control	DCK-203/A49E-6	A-10A
Lead Computing Gryo	CN-1377/AWG	F-15A
CONTROL & DISPLAY		
HUD	AVQ-7 AVQ-20 ( )	A-7D (A-4) F-15A A-10A
HSI	AQU-6A AJN-18	A-7D/A-10A F-15A
ADI	ARU-21/A ARU-( )	A-7D A-10A
VSD	OD-60A	F-15A
Map Display	ASN-99A	A-7D
Recorder	ASH-28	F-15A
Acceleration Counter	A/A37J-8	F-15A
FLIGHT CONTROL		
	ASW-26 ASW-30 ASW-38	A-7D A-7D F-15A

*Aircraft series shown in brackets denote other known applications of the particular equipment in similar purpose weapon systems.

**DAIS Hot Bench Equipment.

Air-Ground Attack

The primary role of the air-ground attack equipment is to perform those functions required to accurately locate enemy positions and successfully destroy designated targets. It will be necessary to accomplish those functions by using predetermined enemy location information and/or real-time designated target information while in the combat area.

Selection Rationale

For Several years, the primary equipment used to perform these functions has been the attack radar. Due to its continued success in accomplishing these functions, a forward looking radar (FLR) of the attack radar type was selected. Its basic functions include determination of slant range and bearing to specified targets and display of this information on a visual presentation for use in bombing, navigation or steering calculations.

A motion picture camera was included in the aircraft to enable recording pictures of the battle/target area for either reconnaissance or battle damage assessment so as to provide detailed information upon which central control can adequately plan and control ensuing tactical missions.

To perform the attack portion of the CAS mission, the aircraft must be capable of delivering weapons. The DAIS CAS aircraft complement will include a missile launcher and gun and will have the capability to deliver bombs and missiles.

Exclusion Rationale

Illuminated low light level television (ILLTV), laser target seeker (LTS) and forward looking infrared (FLIR), while potentially helpful for target location and surveillance, were not included in the current CAS configuration because these systems were still in final development during the time frame of a current DAIS. However, LTS and FLIR functions have been selected for the 1980's configuration.

A lead computing gyro was not included because its outputs (azimuth gimbal angle, evaluation gimbal angle, and normal acceleration) can be obtained from an inertial navigation system (INS).

The tactical computer is a special purpose computer; thus, in accordance with the DAIS concept, it has been omitted and its function placed in a core processor.

Controls and Displays

The controls and displays (C/D) are to present to the pilot all of the information and provide the control required to totally manage the airplane performance and flight dynamics, and accomplish the tasks required in the CAS mission. Efficient application of C/D technology in arrangement, configuration, integration, and automation is essential in order to fulfill these requirements in an expeditious manner.

Selection Rationale

Since the primary role of the CAS airplane will be in support of our own troops, visual target identification and attack will be required when permitted by the weather. Therefore, a head-up display (HUD) with displayed attack symbology is included as a DAIS element for use in visual attack. The predicted current impact point should be displayed on the HUD so that the pilot is required only to steer the impact point to line up with the target and to command release at coincidence of the two. The HUD will provide the pilot with flight information and command symbology for takeoff cruise, head-up weapon delivery, and landing.

To provide a primary navigation display, a horizontal situation indicator (HSI) is required. Its basic function is to combine and present, on one display, the aircraft bearing and distance to selected reference points.

As a source of roll and pitch information for pilot use, an attitude director indicator (ADI) is included.

Another function needed is that of a map display. This is a primary aid during the attack mode. It provides the pilot with a continuous, automatic presentation of the relative position of the aircraft with respect to designated points on the terrain over which it is flying.

The information normally presented on the basic cockpit instruments for aircraft system management and monitoring must also be displayed. This includes status inputs from engine, hydraulic, and electrical systems. To perform these functions in a simplified manner, multipurpose displays (MPD) have been chosen for inclusion.

The equipments discussed above deal basically with display functions. In conjunction with this, capabilities must be provided to control these displays as well as such other functions as stores management and central integrated test. To perform such control an integrated multifunction keyboard (IMFK) and multifunction control panels (MFCP) are included.

The arrangement and configuration of the C/D equipment must be convenient, accessible, unambiguous, and must conform to airframe restrictions. Maximum integration of this equipment is necessary to minimize task loading and space requirements for one-man operation. Maximum information consistent with clutter restrictions must be provided on each display and multiple functions must be available on integrated control panels. Task loading must be further reduced by maximum automation of functions (e.g., MODE CONTROL, EXCEPTION DISPLAYS) so that the pilot can perform as a weapon system manager who is required to act only for high priority decisions and is relieved of continuous monitoring duties related to overall system performance.

Key factors in implementing this baseline system are: (1) conservation of panel space for one-man operation, (2) flexibility and standardization, (3) fault tolerance, and (4) industry capability. Figure 6 is an artist's sketch of the arrangements of such a C/D system for DAIS.

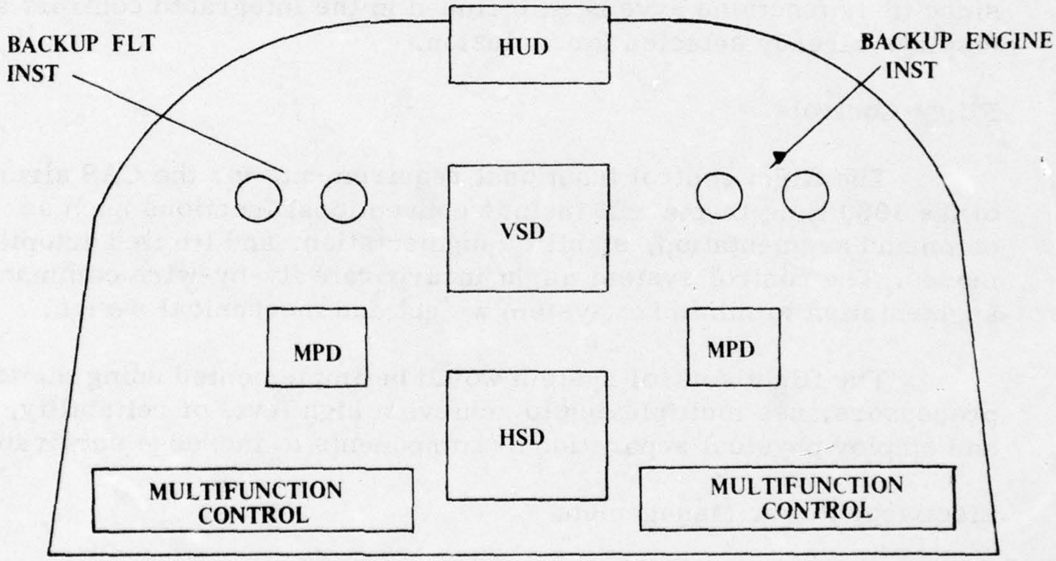


FIGURE 6 DAIS C/D SYSTEM

Exclusion Rationale

Dedicated controls are required for some areas such as armament, communication, master mode keyboard (MMK), power/start-up panel (PSP) and flight controls. They have not been included because of their unique nature with respect to the DAIS concept; i.e., safety of flight, data rates, or display and control format preclude their integration. Many of these functions are included in the equipment selected to perform the CAS mission and are, thus, described in Section IV.

Conventional cockpit instruments, such as engine instruments, bearing distance heading indicators (BDHI), etc., have been excluded since their functions have been included in the integrated controls and displays already selected for inclusion.

Flight Controls

The flight control functional requirements for the CAS aircraft of the 1980 time frame will include conventional functions such as command augmentation, stability augmentation, and limited autopilot modes. The control system might incorporate fly-by-wire command augmentation to minimize system weight and mechanical design.

The flight control system would be implemented using digital processors, use multiplexing to achieve a high level of reliability, and employ physical separation of components to increase survivability.

Electrical Power Management

The electrical power supply system will be required to deliver 115-volt, 3-phase, 400-hertz ac power, and 28-volt dc power. Constant speed drive control is required to regulate the generator frequency at 400 hertz. Voltage regulation, system monitoring, status reporting, and system protective functions will be required. An emergency generator and a battery are required to supply limited power in the event of failure of the main power system.

Central Integrated Test System (CITS)

The test requirements for the CAS airplane stem from two principal mission-related items. First, the CAS airplane will be required to operate from forward bases which will not have extensive test or maintenance facilities. Secondly, the probability of mission

success is increased by the capability of inflight fault detection and graceful degradation to other system configurations. For these reasons, the DAIS system will be required to have the capabilities to test its own performance, to isolate detected failures to an LRU and, wherever possible to a shop replaceable unit (SRU), and to report the test results to the system operator.

A CITS has been selected to perform the test functions. Several types of tests will be required. End-to-end testing with "Go/No-Go" results will be used to determine if the system is ready to be placed in an alert status. Required inflight tests include (1) periodic (i.e., once per second) testing of the computing and interface units, and (2) continuous testing of parameters by comparison or by reasonableness.

SUMMARY

This section has dealt with the CAS mission and the functional requirements for a DAIS-configured aircraft performing such a mission. These functional requirements serve as the basis for identifying specific equipments for the current and 1980's configurations.

Identification of these equipments required knowledge of what is currently available in military inventory as well as projecting technology to determine what will exist and be available in the 1980's time frame. The first of these tasks, the determination of currently available relevant avionic subsystems, was performed through an avionics survey as described in the following section.

III. AVIONICS SURVEY

APPROACH

In order to develop a realistic baseline avionics suite, a survey was made of equipments available in current military inventory and used on aircraft that are used to perform CAS missions. Equipment in all Air Force and Navy aircraft that fall into this category were included in the survey. The list of equipment most representative of current CAS avionics is shown in Table 1.

The table indicates that, for certain functions or subsystems, there is a choice of equipment fulfilling identical functions in the same weapon system. The explanation for this is the occurrence of weapon system modernization accomplished by either changes during production or the retrofitting of existing aircraft.

Information on these equipments was gathered from a review of technical order publications for operation, maintenance, and overhaul. Available manufacturers' literature was also considered extensively. For each equipment, a technical description package was prepared. They contain summaries of the equipments reviewed as candidates for inclusion into the current or mid-1980s DAIS conceptual design configurations. A sample worksheet is depicted in Figure 7. The decision processes that resulted from the analysis of this data are described in Sections IV and V.

WORK PACKAGES

These synopses were provided to the Air Force as a backup data package. They are organized by function group and subsystem type. The six function groups include: navigation, communication, electronic countermeasures, air-ground attack, control and display, and flight control.

The set of data for each equipment includes one sheet of summary information on the whole subsystem, a sheet of information for each line replaceable unit (LRU), and a reference to wiring and block diagrams. The first page of each data set, as shown in Figure 7, describes the complete subsystem and includes identification by function (1), subfunction name (2), AN nomenclature (3) and aircraft application (4), as well as the manufacturer's name (5) and

—— of ——

Function Group: 1 Cat No.:

Subsystem: 2	Nomenclature: 3
Mfr.: 5	Mfr. Model: 6
Aircraft Application: 4 ☐ A-7 ☐ A-10 ☐ F-15 ☐ Other:	
No. of LRUs:	MTBF: 7 hrs. Basis:
Total Wt.: 9 lbs. Total Vol.: 10 cu. ft.	Price: $ 8 Basis:
Power Reqts: 11 AC Three Phase ____ V ____ Hz ____ VA AC Single Phase ____ V ____ Hz ____ VA AC Single Phase ____ V ____ Hz ____ VA DC ____ V ____ W	Cooling: ☐ Ambient ☐ Forced If forced, minimum is: 12 ____ lbs/min. @ ____ °F
Dynamic Constraints: 13	Assoc. Equipt.: 14
Performance: 15	
Output Data (Type & format): 16	
Anticipated Maintenance: 17	
Attached Diagrams: ☐ Interconnection Wiring ☐ Functional Block ☐ Other:	

Figure 7 SUBSYSTEM DATA

and model number (6), mean time between failures (MTBF) (7), and price (8), subsystem physical characteristics such as overall weight (9), volume (10), power (11) and cooling requirements (12) are also noted. Similarly, the dynamic constraints (13) (such as temperature, vibration, and altitude limits) and associated equipment (14 (including antennas, mounts, and other interfacing subsystems) are listed. Further information is recorded on the pertinent performance characteristics (15) and the type and format of the output data (16) of that subsystem. Lastly, anticipated maintenance actions (17) are noted.

One data sheet for each LRU in the subsystem, as shown in Figure 8, follows the subsystem data sheet. The first information on the page is similar to that of the summary sheet and contains: the subsystem name (1), LRU name (2), LRU nomenclature (3), manufactirer (4), model number (5), aircraft application (6), MTBF (7), and price of the LRU (8). The LRU physical characteristics - dimensions (length, height, width) (9), volume (10), weight (11), power requirements (12), and cooling requirements (13) - are recorded next. The functions/performance parameters (14) and any special constraints (15) upon operation of the LRU are noted. The bottom section of the page (16) describes the subassemblies of the LRU with respect to module identification, module name, type of assembly (sensor, core, power supply, control/display, etc.) and other information pertinent to that subassembly.

Subsystem functional block diagrams and wiring diagram listings complete the data package.

The technical description packages cover all of the equipments considered (even though some were not selected) for the current and 1980s DAIS-configured CAS aircraft avionics suite. This data was included to allow maximum flexibility for the LCC model user to vary the specific choices of equipment for a particular function or to reconfigure the CAS conceptual design for a different purpose; e.g., air superiority.

Note that block 16 of Figure 8, the LRU subassemblies' descriptions, has resulted in functional divisions according to the manufacturer's design criteria. Some of these equipments exhibit a natural adaptability for modification to DAIS purposes by partitioning between subassembly modules. Others, to the contrary, exhibit a physical organization significantly less inclined to being reconfigured for a DAIS CAS aircraft.

Subsystem: Cat No.: 1

LRU: 2	Nomenclature: 3
LRU Mfr.: 4	Mfr. Model: 5
Aircraft Application. 6 ☐ A-7 ☐ A-10 ☐ F-15 ☐ Other:	
MTBF 7 Hrs. Basis:	Price $ 8 Basis.
Power Reqts: 12 AC Three Phase ____ V ____ Hz ____ VA AC Single Phase ____ V ____ Hz ____ VA AC Single Phase ____ V ____ Hz ____ VA DC ____ V ____ W	Height: in. Width: 9 in. Length: in. Volume. 10 cu. ft. Weight. 11 lbs.
Cooling Reqts. 13 ☐ Ambient ☐ Forced If forced, minimum is: ____ lbs/min. @ ____ °F	
Functions/Performance. 14	Special Constraints: 15
Ident. Subassy. Type Other Info. 16	

Figure 8 LRU DATA

A second backup data package delivered to the Air Force contains technical description packages, equivalent in form to those used in the first, which provide detailed summaries for each of the core element equipments.

The technical description packages delineate the overall population of avionics subsystems reviewed for the purposes of the DAIS conceptual design configurations and describe the assembly of technical data into work packages to form a reference library. The following section will discuss the selection, from that population, of appropriate subsystems for a current DAIS conceptual design configuration and their partitioning for a DAIS-configured implementation.

IV. CURRENT DAIS EQUIPMENT SELECTION AND PARTITIONING

EQUIPMENT SELECTION

A two-step procedure was used in arriving at a selection of avionics for a current DAIS-configured CAS aircraft. The first step was a nominal selection of generic equipment capable of performing the functions specified in Section II. The second step was to refine the selection of equipment to specific nomenclatured subsystems which are capable of performing the required mission functions and also meet certain selection criteria. These procedures resulted in a baseline system of current avionics capable of fulfilling a CAS mission.

CAS FUNCTIONS

Once the available data was accumulated, the next consideration was applicability of a particular subsystem function to the CAS mission. In some instances, the available choices of equipment to perform a particular function offered no distinct advantages. This was due to the fact that they consisted of significantly different means to accomplish a given function. In other instances, available choices included equipment with a multiple function capability. Specific rationale for equipment selection decisions for each area of the mission function was given in Section II.

PRIOR DAIS AVIONICS STUDIES

Previous DAIS avionics studies have been conducted and some equipment and functions were selected. In order to facilitate comparison with other selections, Table 2 summarizes results of the General Dynamics [1], Texas Instrument [4], and Honeywell [2] trade-off studies. The separate functions and equipments are shown within the general categories of: navigation, communication, countermeasures, identification, air-ground attack, and control and display. Some positions in the table show two possible equipments; in other places, a dashed line (----) is used to indicate that there was either no selection or no discussion of that function in the particular study.

Table 2   SUMMARY OF CAS TRADEOFF STUDIES

FUNCTION	GENERAL DYNAMICS	TEXAS INSTRUMENTS	HONEYWELL
NAVIGATION			
HARS	HARS (Compass, Slave, & DG) Heading Attitude	---------	---------
Inertial	IMS (Fast Reaction Stored Heading, Inflight & Gyrocompass Align) Position 0.5 nm/h (CEP) Vel 1-2 ft/sec	Strap Down ASN-90	Carousel IV Pos 2-5 nm/h (2σ) R& P 0.1-1.0 deg LN-30 Class ASN-101 Pos < 1nm/hr Att 0.01 deg (resolution) Strapdown Pos 1-3 mph (CEP) Vel 3 kts *Heading .5-1 mil/hr* Floated Gyros 2-3 nm/hr syst Dry Gyros < 1nm/hr syst
UHF/ADF	ADF	ARA-50	----------
TACAN	TACAN	ARN-52	-----------
VOR/ILS	ILS	ARN-58A	-----------
LORAN		LORAN	ARN-199 ARN-92 ARN-101 (Pref)
ADC	ADC Mach No. *True Airspeed* Indicated Airspeed Angle of Attack Pressure Altitude Rate of Climb Angle of Sideslip	CP-953A/AJQ	ADC Alt. Sen. 0.003 Hg " Acc. ± 15' SL " " ± 20' 10K " " ± 40' 30K TAS Pres. Alt. Delta Alt. Hold

Table 2 SUMMARY OF CAS TRADEOFF STUDIES (Continued)

FUNCTION	GENERAL DYNAMICS	TEXAS INSTRUMENT	HONEYWELL
NAVIGATION (Continued)			
Doppler Radar	-------	-------	Doppler Design Study
Radar Beacon	-------	APN-154	---------
Radar Altimeter	Radar Alt. Altitude Alt. Rate Min Alt.	APN-141	---------
COMMUNICATIONS			
UHF Radio	UHF	ARC-51BX	ARC-144 ARC-116 7180-5
HF	HF	--------	
VHF/FM	--------	FM-622A	ARC-114
VHF/AM	--------	--------	ARC-115
Secure Voice	Secure Voice	Juliet 28	---------
Intercom	---------	AIC-26	---------
Data-Link	Data-Link	--------	ASW-27
COUNTERMEASURES			
RHAW	---------	---------	---------
IR Tail Warning	---------	---------	---------
ECM Pod	---------	---------	---------
Chaff & IR Flares	---------	---------	---------
	---------	APQ-71	---------
Jammer	---------	ALQ-87 ALQ-101	---------
ECM Destruct	---------	MX-8261/ASQ	---------

Table 2 SUMMARY OF CAS TRADEOFF STUDIES (Continued)

FUNCTION	GENERAL DYNAMICS	TEXAS INSTRUMENT	HONEYWELL
IDENTIFICATION	Identification-Data		
IFF/SIF	IFF	APX-72	APX-72
AIR-GROUND ATTACK			
ILLLTV	ILLLTV	-------	-------
LSS	Laser Spot Seeker (LSS) Range to Target Alt above Target	LSS	-------
FLIR	FLIR Visual of Thermal Contrasts Range to Target Alt above Target	FLIR	-------
Angle Rate Bombing System	-------	-------	-------
Attack Radar	Attack Radar Visual Contrasts Slant Range Bearing To Range Rate	APQ-126	-------
ATS	-------	Auto Tracking System	-------
Tactical Computer	------	ASN-91	-------
CONTROL & DISPLAY			
HSD	HSD	-------	HSD
VSD	VSD	-------	VSD
HUD	HUD	AVQ-7	HUD
MPD	2 MPD	-------	MPD

Table 2 SUMMARY OF CAS TRADEOFF STUDIES (Continued)

FUNCTION	GENERAL DYNAMICS	TEXAS INSTRUMENT	HONEYWELL
CONTROL & DISPLAY (Cont'd)			
IMK	-------	-------	-------
MFP	-------	-------	-------
SCU	-------	-------	-------
HSI	-------	AQU-6A	-------
ADI	-------	ARU-21A	-------
Altimeter	-------	AAU-19A	-------
Mach/AS Ind.	-------	A-7	-------
TAS Ind.	-------	A-7	-------
Vert. Vel. Ind.	-------	A-7	-------
Stby Att. Ind.	-------	A-7	-------
Caution and Advisory Panels	-------	A-7	-------
AOA Ind.	-------	A-7	-------
Map Display	-------	ASN-99	-------
Weapons Management	Weapon Management Stores Control Switching Indicators Status	A-7	-------
Electrical Power Management	Electrical Power Management Single Engine with Single Generator Aux Gen.	A-7	-------

Table 2 SUMMARY OF CAS TRADEOFF STUDIES (Continued)

FUNCTION	GENERAL DYNAMICS	TEXAS INSTRUMENT	HONEYWELL
FLIGHT CONTROL SYSTEM	Flight Control System Command Augmentation Stability " Limited Autopilot Modes	Fly-By-Wire Stability augmentation system (SAS)	Stability Aug. Att & Head Pilot Relief Rate Gyros $\pm$ 30 °/sec $\pm$ 200 °/sec $\pm$ 400 °/sec Accel $\pm$ 2g $\pm$ 6g Fly-By-Wire Digital Flight Control Control - Configured Vehicle

In addition to listing the specific functions/equipments selected by the previous studies, Table 2 includes some of the outputs and accuracies associated with those choices. These related data were evaluated in conjunction with the functions and equipments listed to arrive at the current DAIS conceptual design configuration equipment selection.

SUBSYSTEM SELECTION CRITERIA

To select specific representative equipments for the current DAIS design configuration the following criteria was imposed:

1) Both the functional mission requirements and the flight dynamics for a CAS aircraft must be met.

2) Selected equipments must be representative of the current military inventory.

3) If equipments were basically equal, then the final selection is based upon the availability of performance, reliability, maintenance, and cost data.

These criteria, when overlaid on the available avionics shown in Table 1, permitted a selection of specific nomenclatured subsystems for the current conceptual design configuration.

CAS EQUIPMENT SELECTION FOR CURRENT CONFIGURATION

Starting with the candidate systems summarized in Tables 1 and 2, the above selection criteria were imposed to make specific equipment/sensor selections. The result of this baseline selection is shown in Table 3. "Most modern" was not necessarily a driving factor; "most representative of current inventory" was considered to be of greater importance. Digital outputs, per se, were not given any special merit. Due to the fact that the multiplex bus interface is a recently specified capability, implementation will require some input-output (I-O) circuitry for almost any equipment selection.

The ADC chosen was that of the A-7D for the specific reason that its design flight profile; i.e., the attack mission, is similar to that of the CAS mission. Flight dynamics considerations negated the choice of countermeasures equipment from an F-15A which were incorporated within the AS airframe purely for aerodynamic streamlining. Such relocation with its attendant complications is not a reasonable constraint for a CAS aircraft which does not have the requirement for streamlining to enhance aerodynamic performance.

PARTITIONING

The previous sections have discussed the avionics functions required for a CAS aircraft and the sensor selection that would perform those functions in a current DAIS application. This section describes the partitioning of the current sensors into functional segments at the SRU level and also discusses those equipments excluded from partitioning.

Each equipment was partitioned so as to conform to the DAIS concept; i.e., they were partitioned at the subassembly level into three categories: sensor, processor, control and display. Where appropriate, power supply functions were identified for possible inclusion in a central DAIS power bus at some future time.

Since these equipments were not developed under the DAIS concept, many of the subassemblies perform functions that fall into more than one DAIS functional category. Where possible, these multifunction subassemblies were assigned to the functional group corresponding to the predominant function of the subassembly. In other instances, this determination could not be made and the subassembly was then designated as being multifunctioned.

Table 3 AVIONICS EQUIPMENT SELECTION

CURRENT CONCEPTUAL DESIGN CONFIGURATION FOR A CAS AIRCRAFT

Subsystem	Nomenclature		Source Aircraft
Function: NAVIGATION			
INS	ASN-90	x	A-7D
UHF-ADF	ARA-50	x	A-7D
TACAN	ARN-52		A-7D
VOR-ILS	ARN-58A	x	A-7D
ADC	CP-953A/AJQ		A-7D
Beacon	APN-154	x	A-7D
Radar Altimeter*	APN-141	x	A-7D
Function: COMMUNICATIONS			
UHF	ARC-51	x	A-7D
HF	ARC-123	x	F-111A
VHF-FM	FM-622A	x	A-7D/A-10A
Secure Voice*	TSEC/KY-28		A-7D/A-10A/ F-15A
Intercom	AIC-25	x	F-111A
Data Link	ASW-25A		A-7E
IFF	APX-72	x	A-7D
Function: COUNTERMEASURES			
RHAW*	ALR-46		A-7D
IR Tail Warning*	AAQ-4		RF-4C
Function: AIR-GROUND ATTACK			
FLR	APQ-126	x	A-7D
Function: CONTROL & DISPLAY			
HUD	AVQ-7		A-7D
HSI	AQU-6/A		A-7D/A-10A
ADI*	ARU-21/A		A-7D
Map Display	ASN-99A		A-7D
MPDs	**		**
IMFK	**		**
MFCPs	**		**

*Excluded from partitioning (see Section IV).

**Not in current aircraft inventory but development is dictated via adoption of DAIS concept.

x - Hot Bench Equipment

Each of the avionics systems surveyed was partitioned as described previously by functional area. Those functions which could be performed in a core element were so designated. It is conceivable that some of the computer functions might better be performed by processors remaining with the sensors instead of the core element. This subject will be pursued in the processor discussions. The control/display functions were partitioned separately for later integration into multipurpose displays.

Exclusions from Partitioning

Not all of the current avionics selected (as shown in Table 3) should be partitioned; those equipments which have been excluded from partitioning are listed below along with the rationale for their exclusion:

- Equipments with unique installation requirements:

  Equipments such as ECM pods, chaff and flare dispensers, and IR tail warning operate as independent systems and are subject to quickly changing, field-modified configurations. This group also includes the motion picture camera, missile launcher electronics, and gun and missile control electronics which obviously have special requirements. On the other hand, control of these subsystems and display of data associated with their operation (i.e., the ECM threat, weapons status, etc.) are desirable aspects of the integrated system. Thus, while these subsystems have not been partitioned, their control and display functions still remain part of the DAIS avionics control and display system as shown in Figure 10.

- Special purpose equipment:

  The Radar Homing and Warning (RHAW) performs specialized functions requiring much higher speed processor operations than that required by the other avionics and, therefore, requires a dedicated computer. Nevertheless, an interface exists with the multiplex bus for control and display purposes.

- *Safety of flight:*

  Several other functions will not be partitioned because their failure to perform their specified functions affect safety of flight for the aircraft. Two equipments in this category are the AFCS (autopilot) and the radar altimeter.*

- Standard inventory items:

  Certain functions will be fulfilled by equipments provided to the aircraft SPO by other organizations as standard items. These include Secure Voice, ADI, and certain flight and engine instruments.

Current DAIS Avionics Partitioning

This section provides a summary in Table 4 of the equipment selected as being representative of the current DAIS avionics suite partitioned to the subassembly level. The summary table is subdivided into the five functional groups: navigation, communication, countermeasures, air-ground attack, and control and display. Within each functional group, the specific equipments are subdivided by line replaceable unit (LRU). The functions of each subassembly of every LRU are partitioned as previously described. Table 4, "Current Avionics Partitioning", also contains a catalog number (cat. no.) for each equipment included. It provides a cross reference to the similarly numbered summary sheets (in the backup data package, see Section III) which contain further details on each subsystem. Those equipments which have been excluded from partitioning have been included in the table for the sake of continuity and are designated "NA" (not applicable).

The table lists all relevant equipments but concerns itself specifically with the major LRUs of the subsystems being partitioned. Mounts, couplers, and antennas are not included unless the particular one is complex in nature. For example, a UHF blade antenna would be excluded while the FLR (gear assembly, roll attitude harness, etc.) would be included. Computer LRUs; e.g., ASN-91 Tactical Computer Set, are specifically excluded from the table as their entire purpose is accommodated by the DAIS core processor elements.

*Computation of the radar altimeter output, i.e., altitude, is simply a measurement of the elapsed time between transmission and reception of an electromagnetic signal. Use of the processor for this does not appear to be justified.

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP NAVIGATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ASN-90 INERTIAL MEASUREMENT SET	CN-1260 INERTIAL MEASUREMENT UNIT	ACCEL. (2 AXIS) ACCEL. (VERTICAL) GYRO (VERTICAL) GYRO (AZIMUTH) GYRO ELEC. ACCEL. ELEC. TEMP CNTL. (CLUSTER) TEMP CNTL. (GIMBAL) COMPENSATION CARD GIMBAL ELEC. SWITCHING ELEC. RESET INTEGRATOR TEMP CNTL. (AUX.)			POWER SUPPLY	1.2.1
	C7796 or C7822 INERTIAL MEASUREMENT SET CONTROL			GRID SLEW SWITCH MODE SELECTION VARIABLE RESISTOR CNTL. DIFFERENTIAL XMTR		
	PP-6141 ADAPTER-POWER SUPPLY	HEADING REPEATER	SEQUENCER 1&2 RELAY & DRIVER 800 Hz MOD. ELECTRONIC CNTL.		POWER SUPPLY 1&2 POWER SUPPLY 3, 4 & 5 BATTERY CHARGER STORAGE BATTERY	

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP NAVIGATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ARA-50 UHF/ADF	AM-3624 AMPLIFIER-RELAY ASSY.	INTERCOM BOX RELAY ASSY. ELECT. CONT. AMP.				1.3.1
	AS-909/ARA-48	ANTENNA MOTOR SYNCHRO TRANSMITTER CHOPPER RATE GEN.				
	R-1286/ARR-69 UHF/AM RADIO	PRESELECTOR RF FILTER RF MOD. IF-AF MOD				
	C-1457A/ARR-40 RECEIVER CONT.			RECEIVER CONT.		
ARN-52(V) TACAN	RT-384 RECEIVER-TRANSMITTER	RF MOD. ANT. SELECTOR BEARING A MOD. BEARING B MOD. BEARING MECH. MOD. MAGAMP PH. DETECTOR RANGE A MOD. RANGE B MOD. BEARING DECODER RANGE DECODER RANGE MECH. MOD. AIR TO AIR MOD. FILTER BOX ASSY. ANT. LINE FILT. POWER LINE FILT. ELAPSE TIME IND.			POWER SUPPLY	1.4.1
	C-2010 CONTROL, RADIO SET			CHAN. SEL. KNOBS IDENT. TONE LEVEL CONT. ON-OFF & MODE SELECTOR SW.		

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP NAVIGATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ARN-52(V) TACAN	MT-1729 MOUNTING	TRANS. REC. MODE RELAY. AIR-TO-AIR MODE RELAY RECEIVE MODE RELAY				1.4.1 (Cont.)
ARN-58 INSTRUMENT LANDING SYSTEM	R-844 RADIO RECEIVER	G.S. RF, OSC. & MIXER G.S. IF G.S. AUDIO CHASSIS MKR. BEACON RF, IF MKR. BEACON AF				1.5.1
	R-843 RADIO RECEIVER	RF, OSC. & MIXER IF AUDIO CHASSIS				
	C-3491 RECEIVER CONT CONTROL			WAFER SW. TOGGLE SW. VAR. "L" PAD 2 PANEL-LIGHT ASSY. FREQ. IND.		
CP-953A/AJQ AIR DATA COMPUTER	CP-953A AIR DATA COMPUTER	TAS TRIGGER MACH/ALT. TRIGGER TAS SERVO ALT. SERVO MACH SERVO BUFFER AMP. STATIC PRESSURE SENSOR PRESSURE RATIO SENSOR ALT. ENCODER ALT. REP. SYNCHRO ALT. HOLD SYNCHRO ALT. SERVO M/G MACH SERVO M/G MACH POT. ALT. POT. STACK ALT. HOLD POT. TAS SYNCHRO (2) TAS SERVO M/G TAS POT.			POWER SUPPLY	1.7.1

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP NAVIGATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
APN-154(V) RADAR BEACON	RT-763 RECEIVER-TRANSMITTER	DECODER RF ASSY. INPUT MODULATOR IF AMP RF ASSY. OUTPUT			POWER SUPPLY	1.9.1
	C-4419 CONTROL			CONTROL/DISPLAY		
	CU-1104 DUPLEXER-CIRCULATOR	DUPLEXER-CIRCULATOR				
APN-141(V) RADAR ALTIMETER SET	NA					1.10.1

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP COMMUNICATIONS

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ARC-51 UHF RADIO	RT-650 RECEIVER TRANSMITTER	RCVR. RF PREAMP. 1st & 2nd IF AMP. 3rd IF AMP. MODULATOR & AUDIO SPECTRUM GEN. POWER AMP. GUARD RCVR. MECHANICAL TUNER MAIN CHASSIS			AC/DC POWER SUPPLY	2.1.1
	C-3984 RADIO SET CONTROL			FUNCTION SEL. CHANNEL SEL. FREQUENCY SEL. VOLUME CNTL.		
ARC-123 HF RADIO	RT-822 RECEIVER - TRANSMITTER	WIDEBAND AMP. 1MHz FREQ. STD. FIXED FREQ. GEN. R-T LOCAL OSC. RF AMP. PARAMETRIC AMP. PUMP AMP. 124.7 MHz IF 700KHz IF AUDIO CARD			AUX. POWER SUPPLY	2.2.1
	AM-4573 AMPLIFIER- POWER SUPPLY	RF AMP. OUTPUT NETWORK LOGIC MODULE AGC/ALC AMP. RF DRIVER BIAS/ALC PHASE DETECTOR LOGIC MODULE			POWER SUPPLY RELAY BOARD COMPONENT BOARD RECTIFIER BOARD	

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP COMMUNICATIONS

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ARC-123 HF RADIO	C-7073 RADIO SET CONT.	VCO AND BUFFERS LOOP 1 LOGIC LOOP 2 LOGIC REFERENCE GEN. RF MIXER			VOLTAGE REG.	2.2.1 (Cont)
FM-622A RADIO SET VHF-FM	FM-622A RADIO SET RECEIVER TRANSMITTER	VHF TUNER ASSY. RF OSC. ASSY. XTAL REF. SYS ASSY. IF AMP ASSY. RF CONTROL ASSY. HOMER, DET. AMP ASSY. AUD. FREQ. AMP. ASSY. OSC. BUFFER ASSY. RF AMP. ASSY. ISOLATION AMP. ASSY. AMP - MOD. ASSY. REC. - TRANS. CHASSIS GEARBOX ASSY. IF ATTENUATOR ASSY.			VOLTAGE REG. ASSY. POWER SUPPLY ASSY.	2.3.1
	C-921/FM RADIO SET CONT.			FREQ. SEL. & IND. MODE SELECTOR VOLUME CONTROL SQUELCH SWITCH		
TSEC/KY-28 SECURE VOICE	NA					2.5.1
AIC-25 INTERCOMMUNI-CATION SET	C-6567 INTERCOMMUNI-CATION SET CONT.	AUDIO FREQ. AMP. AUDIO FREQ. AMP. TERMINAL BOARD		CALL SWITCH VOLUME CONTROL SELECTOR SWITCH MONITOR SWITCH	RELAY RELAY SOCKETS	2.6.1

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP COMMUNICATIONS

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
AIC-25 INTERCOMMUNI- CATION SET	C-6624 INTERCOMMUNI- CATION STATION	AUDIO FREQ. AMP AUDIO FREQ. AMP TERMINAL BOARDS TERMINAL BOARDS		CALL SWITCH VOLUME CONTROL	RELAY RELAY SOCKET	2.6.1 *(Cont)*
ASW-25A DIGITAL DATA COMMUNICATION SET	CV-2230A CONVERTER RECEIVER	SYNTHESIZER RECEIVER	DC/DC CONVERTER REGULATOR DRIVERS & DISC. LOGIC DC/DAC & DATA RECONS. DC/DAC & 320KHz OSC. LOGIC & DATA STORAGE			2.7.1
	C-7100 CONTROL PANEL			CONTROL PANEL		

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP COMMUNICATIONS

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
APX-72 IFF	RT-859 RECEIVER- TRANSMITTER	MODULATOR SENSITIVITY AMPLIFIER POWER AMP. DET. & VIDEO AMP. PRESELECTOR OSCILLATOR LOW PASS FILTER	PROCESSOR DECODER MODE 4 ENCODER CLOCK ENCODER CONTROL ENCODER GATING DELAY LINE	MODE SWITCH ASSYS.	POWER SUPPLY	6.1.1
	C-6280P TRANSPONDER CONTROL UNIT			TRANSPONDER CONTROL UNIT		
	KIT-1A/TSEC MARK XII COMPUTER	MARK XII COMPUTER				
	IFF EMERG. SWITCH			IFF EMERGENCY SWITCH		
	IFF CONTROL PANEL			IFF CONTROL PANEL		
	MT-2873/APX COMPUTER SHOCK MOUNT	DIPLEXER, UHF/IFF ANTENNA CAP. ASSY.				

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP COUNTERMEASURES

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ALR-46 RHAW	NA					3.1.1.
AAQ-4 IR TAIL WARNING	NA					3.2.1

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP AIR-GROUND ATTACK

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
APQ-126 FORWARD LOOKING RADAR	CP-954 AIR NAVIGATION COMPUTER		TEST MONITOR COMMAND GEN. TEMPLATE GEN. ALTIM. OVERRIDE MODE LOGIC			4.4.1 (Cont.)
	C-8252 RADAR SET CONTROL			POWER SWITCH FREQ. SELECTOR POLAR SWITCH ANTENNA TILT MODE SWITCHES RELAYS		
	C-8255 RADAR SET CONTROL	DISCRETE SUBASSY. *CARRIER BOARD*	BCD COUNTER	TERRAIN CLEAR. SEL.		
	IP-952 MULTIPLE AIR NAVIGATION INDICATOR	VERT. SWEEP PREDRIVER WRITE GUN DRIVER YOKE DRIVER INTENSITY COMPEN. HORIZ. SWEEP PREDRIVER		EDGE LIGHT PANEL	WRITE GUN PS DUNKING XFMR	
	SG-811 SWEEP GENERATOR			SWEEP GENERATOR HYPERBOLIC FUNCT. GEN. LOGIC SWITCHING RHAW/SIDS INTERFACE SWEEP RESOLVER LINE DRIVER TV DISPLAY ERASE & INTERFACE ALARM MONITOR		

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP AIR-GROUND ATTACK

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
APQ-126 FORWARD LOOKING RADAR	SG-811 SWEEP GENERATOR			COUNTER & DECODER STORAGE/FCT. GENERATOR D/A CONV. & ANALOG OUTP BUFFER/CHECK LOGIC INTERFACE BUFFERS TIMING (High & Low Freq.) RANGE & DIVIDER VIDEO (Processor & Detector) ARITHMETIC CONTROL CONTROLLER FAULT ISOLATION (Nos. 1,2 &3) AGR CARRIER		4.4.1 (Cont.)
	MT-4043/APQ-126 RADAR SET MOUNT	GEAR ASSY, ROLL ATT. HARNESS, INTERCONNECT BLOWER, MOUNT				

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP AIR-GROUND ATTACK

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
APQ-126 FORWARD LOOKING RADAR	PP-6130 ANTENNA SCAN PS PROGRAMMER	RECTIFIER/FILTER STABILIZATION CNTL. EMI FILTER ROLL/AZIMUTH CNTL. SCAN PULSE GEN. ELEVATION SERVO AMP. YAW STAB. GEN. DITHER PROG. SYNCHRONIZER PWR. SWITCH CNTL. SCAN PROGRAMMER			+40VDC POWER SUPPLY +200VDC POWER SUPPLY ±20VDC POWER SUPPLY	4.4.1
	T-1091 RADAR TRANSMITTER	MODULATOR TUNING SERVO OVERLOAD PROTECTOR POWER DETECTOR THYRATRON TRIGGER MAGNETRON THYRATRON			HIGH VOLT. ASSY LINE FILTER	
	AS-2272 ANTENNA-RECEIVER	AZIMUTH DRIVE ELEVATION DRIVE LOCAL OSC. RF PULSE GEN. TEST PANEL SUM MIXER PREAMP. DIFF. MIXER PREAMP. AFC MIXER PREAMP. IF PROCESSOR AFC CONTROLLER				

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP CCNTROL/DISPLAY

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
AVQ-7(V) HEAD-UP DISPLAY SET	IP-938 HEAD-UP DISPLAY UNIT	COMBINER & LENS CHASSIS X DEFLECTION AMP Y DEFLECTION AMP VIDEO BITE TUBE UNIT		CONTROL PANEL	HIGH VOLT. POWER SUP. LOW VOLT. POWER SUPPLY	5.1.1
	CP-951 SIGNAL DATA PROCESSOR			DATA INPUT DISCRETE INPUT ADDER MEMORY PROCESSOR CONTROL STORE CONTROL INSTRUCTION REGISTER CORE PLANE DRIVER TRANSISTOR SEQ. CONT. REG. & DRIV. ANALOG INPUTS ANALOG OUTPUTS RATE & DEFLEC. REG. OVERFLOW REGISTER PARAMETER CONTROL FUNCTION CONTROL CLOCK & CHECKOUT	+5V POWER SUPPLY LOW VOLT. POWER SUP	
AQU-6/A HSI	NA					5.2.1
ARU-21/A ADI	NA					5.4.1
ASN-99A PROJECTED MAP DISPLAY SET	CV-2622 SIGNAL DATA CONVERTER	MULTIPLEXER HARMONIC OSC. CONV. TIMING & SUB. DATA BUFFER COMMAND DATA DECODER DECODER ADD. & FRAME SERVO AMP. PERFORMANCE MONITOR			1 & 3 PHASE FULL WAVE BRIDGE RECT. POS. VOLTAGE REG. NEG. VOLTAGE REG. P.S. MON. & LATCH DRIVE	5.3.1

Table 4 CURRENT AVIONICS PARTITIONING

FUNCTION GROUP CONTROL/DISPLAY

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ASN-99A PROJECTED MAP DISPLAY SET	CV-2622 SIGNAL DATA CONVERTER	CONV. STOREB FILM TRAN CONV. STORER SERVO DR. CONV. STORER SERVO DR. ROTOR VOLT. SYNC. GEN. SERVO AMP.				5.3.1 (Cont)
	ID-1665A DISPLAY UNIT	CENTER SECTION TURNTABLE & CARRAGE ORIENT. MG & RES. BLOWER SLIPRING REAR SECTION		FRONT SECTION RANGE INDICATOR COMPASS DRIVE POINTER DRIVE JOYSTICK CONTROL TOTAL TIME IND. FAULT IND.		

CORE ELEMENTS

The four subsystems of the DAIS core central to the DAIS Conceptual Design Configuration are the (1) processor, (2) multiplex bux, (3) controls and displays, and (4) software. The development of standards and techniques associated with these four subsystems has been one of the prime motivations behind the establishment of the DAIS Integrated Test Bed.

In order to reflect the most current thinking with respect to the core elements Dynamics Research Corporation (DRC) has coordinated with AFAL to establish the design baseline. A summary of the constraints imposed on the core element design is given by F. Scarpino and R. Goodstein [5]. Our approach was to first determine the processing requirements for the selected conceptual design configuration described in this report. Then the constraints developed by AFAL were overlaid to establish the core element design configuration.

Core Element Design Requirements

The DAIS concept seeks to standardize avionics, reduce acquisition and support costs, and provide increased flexibility in future avionics systems. To accomplish these objectives the modular core elements are designed to be easily removable and replaceable, easily exchangeable between different aircraft, and readily reconfigurable for different missions. The design objectives can be summarized in terms of the characteristics and goals shown in Tables 5 and 6, respectively.

Control and Display Elements

Control and Display (C/D) core elements for a DAIS-configured CAS aircraft conceptual design configuration must both satisfy mission requirements and conform to the principles of the DAIS concept. After an intensive review of all available C/D subsystems design references, it was determined that Reference [7] most specifically addresses the DAIS core element design problem.*

*The equipments described were selected prior to the finalization of C/D specifications for the DAIS Integrated Test Bed.

Table 5 CORE ELEMENT CHARACTERISTICS

Processor	Multiplex

• 349 KEOPS
• 1 DMA Channel
• 16 Registers
• Flexible Addressing Modes
	• MILSTD 1553
	  • Manchester Code
	  • 1 Megabit
	• Twisted Shielded Pairs
	• High Replication of Modules
	  • Bus Interface
	  • Processor Interface
	  • Subsystem Interfaces

Controls & Displays	**Software**
• Identical CRT Displays • Multifunction Keyboards and Controls • Modular Displays Generator • Plug-In Refresh Memory	• Structured Programming • Transferable Modules • Comprehensive Support Software • Integrated Test Software

Table 6 CORE DESIGN GOALS

Item	Design Goal
Weapon CEP	No Degradation Due to Core Element Function
Memory Use (Highest)	Less than 70%
Timing Load (Highest)	Less than 70%
Bus Traffic	Less than 70%
In-Flight LRU Fault Detection	75%
Pre-Flight LRU Fault Detection	90%
Post-Flight LRU Fault Isolation	95%

The C/D Subsystem recommended by Boeing, under contract to the DAIS Advanced Development Program Office (ADPO) describes a "dual redundant design" consisting of (1) an integrated set of five cathode ray tube displays which interface to the data bus through a display switch/memory unit (DS/MU), two modular programmable display generators (MPDG), and two remote terminal units (RTU); (2) an integrated set of multifunction and dedicated control panels which interface directly to the data bus through two RTUs. The multifunction controls are identifed as follows: (1) integrated multifunction keyboard (IMK), (2) multiple function control panel (MFCP-1) used as a stores management keyboard, and (3) multiple function control panel used as a DAIS Integrated Test System (DITS) keyboard (DK). The dedicated controls are identified as follows: (1) armament panel (AP), (2) sensor controller unit (SCU), (3) communications panel (CP, (4) sensor/map panel (SMP), (5) digit entry keyboard (DEK), (6) master mode keyboard (MMK), and (7) power/start-up panel (P/SP). The controls and displays, functionally integrated through appropriate mission software control modules in the DAIS processors, would be supplemented by a set of standard dedicated instruments to act as a backup in the event of DAIS power failure.

Core Element Architecture

The design objectives call for two multiplex lines, one completely redundant with the other, limiting bus traffic to 70%. To minimize software development costs, reduce logistic support costs, and ease implementation of system specifications, processor software occupies only 70% of capacity. This processor capacity requirement is for final implementation, not a hedge against unspecified growth.

After establishing the processor requirements for the selected conceptual design configuration, it was determined that the AFAL recommended software task allocations could be utilized. The result was the following assignments:

Processor 1: executive, control and display

Processor 2: navigation including air data computations

Processor 3: stores management, weapon delivery, target acquisition, and fixtaking

Processor 4: integrated test system, mission data management, communications management, electrical power management, EW/ECM control.

Core Element Design Configuration

A breakdown of the core elements that meets the functional requirements of the DAIS avionics suite appears below:

1. Processor
   - arithmetic and control unit
   - memory unit
   - I/O unit
   - power supply
   - maintenance/control interface

2. Bus Control Interface Unit (BCIU)
   - processor interface module (PIM)
   - bus control module (BCM)
   - power supply
   - bus interface module (BIM 1 and BIM 2)

3. Remote Terminal Unit
   - MTU - multiplex terminal unit
   - TCU - timing and control unit
   - power supply
   - IM - interface module
   - self test

4. Control and Display
   - digital scan converter (DSC)
   - modular programmable display generator (MPDG)
   - display switch/memory unit (DS/MU)
   - head-up display (HUD)
   - vertical situation display (VSD)
   - horizontal situation display (HSD)
   - multiple purpose display (MPD)
   - stores management panel (MFCP-1)
   - master mode panel (MMP)
   - integrated multifunction keyboard (IMK)
   - data entry keyboard (DEK)
   - sensor/map control panel (SMCP)
   - communication panel (CP)
   - armament panel (AP)
   - power/start up panel (P/SP)
   - mass memory unit (MMU)
   - sensor control unit (SCU)
   - DITS panel (MFCP-2)

The core element technical description packages (see description of backup data package in Section III) contain technical data and definition of each of the above core elements.

Processing Requirements

The processor capabilities for storage and data handling are defined in terms of estimates of the memory and speed requirements of the individual subprograms. Estimates were derived by splitting processing requirements into completely separate, non-related groups. The general design constraints of the "Critical Item Development Specification for the DAIS Processor "[6] were overlaid and the processing requirements for the current DAIS conceptual design were estimated as shown in Table 7.

Table 7 PROCESSING REQUIREMENTS

Subprogram	Processor #	Memory (16-bit words)	KOPS
Executive	1	2000	26.7
I/O	4	2500	120.0
Inertial Navigation	2	5000	54.1
Air Data	2	2500	28.0
Steering	2	1200	13.0
Mission Planning	3	700	0.5
Sight and Designation	3	1000	34.0
Weapon Delivery	3	5000	124.8
Stores Management	3	1000	16.0
Sensor Control	3	300	28.0s
Communications	4	250	1.7
Service Routines	4	500	-
Control and Data Entry	1	7000	4.9
Display Support	1	1300	6.2
CITS	4	8000	-
Total (without redundancy)		38,250	457.9

The next step was to distribute these subprograms among the four processors in accordance with their function allocations and a redundancy factor (of 2). The result is given below.

Processor 1 executive, control and display

20,600 words and 37.8 KOPS

Processor 2 navigation including air data computations

17,400 words and 95.1 KOPS

Processor 3 stores management, weapon delivery, target acquisition, fixtaking

16,000 words and 203.3 KOPS

Processor 4 integrated test, mission data control, communications, power control, ECM control

22,500 words and 121.7 KOPS

For processors with a basic 32,000 word memory of 16-bit words [6], the constraint of maximum usage of 70% of the available memory capacity has been met.

It should be noted that processor and software sizing has counted upon a central integrated test system (CITS) capability. Clearly, the requirement can be varied in magnitude, depending upon the specific system architecture and confidence requirements for fault detection and isolation. In obtaining the above estimates, CITS was assumed to include: preflight discrete checks, inflight monitoring of function discrepancies and operating mode, failure warning and mode change option displays for the pilot, data recording for postflight analysis, and postflight troubleshooting sequences.

Stores Management

The stores management and weapon delivery functions contained herein are primarily software modules in one of the core processor elements. They comprise extremely important CAS functions in that the aircraft weapons are accounted, controlled, and released through this capability. This software computes weapon release and steering signals, as well as missile launch envelopes and ballistic data for air-to-air gun attack modes.

Interface and Multiplex Data Bus

The intent is to achieve low acquisition and maintenance costs. Based upon AFAL efforts to achieve this objective, all sensors will be interfaced with a time-division multiplex data bus developed in accordance with MIL-STD-1553. Interface adapters consisting of Bus Control Interface Units (BCIU), Remote Terminal Units (RTU), or their functional equivalents will maintain a "high replication of modules" as a design constraint. No specific difficulty with practical implementation of such requirements for the test bed or, for that matter, aircraft so configured in the future can be foreseen at this time.

Hence, it is reasonable to envision the basic C/D hardware configuration for a CAS aircraft with DAIS-configured avionics as including:

General controls and displays

- head-up display (HUD)
- horizontal situation display
- vertical situation display (VSD) or attitude director indicator (ADI)
- two (2) multipurpose displays (MPDs)
- integrated multifunction keyboard (IMFK)
- two (2) multiple function control panels (MFCPs)

Interfacing electronics

- display switch/memory unit (DS/MU)
- two (2) modular programmable display generators (MPDG)
- digital scan converter
- mass memory unit (MMU)

With dedicated controls for

- armament
- communications
- master mode keyboard (MMK)
- power/startup panel (P/SP)
- flight controls

Independent, standby instruments are used to provide basic air data, engine, and fuel system parameters.

CURRENT DAIS DESIGN CONFIGURATION

The current DAIS equipments selected and partitioned in this section have been integrated with the core elements to provide the Current DAIS Design Configuration. The results are shown both in layout form and schematic representation in the following pages.

There are many considerations involved in the layout of avionics equipment in an aircraft. Recognizing at least some of the basic considerations, a distribution of DAIS equipment on a functional basis within a CAS aircraft is shown in Figure 9. The contents of each bay and the cockpit avionics are itemized in Table 8. With the exception of the IR jammer, RHAW sensors and some antennas, most of the avionics are located forward of the engine to avoid any heat and vibration problems.

Table 8 FUNCTIONAL AVIONICS FOR DAIS CONCEPTUAL DESIGN CONFIGURATIONS

<u>Forward Avionics Bay</u>

- processor #1
- BCIU #1
- forward looking radar
- air data computer
- LTS*
- FLIR*
- intercommunication set

<u>Cockpit Avionics</u>

- electronic display group
- special purpose displays
- display controls
- mass memory unit
- multifunction controls
- dedicated controls

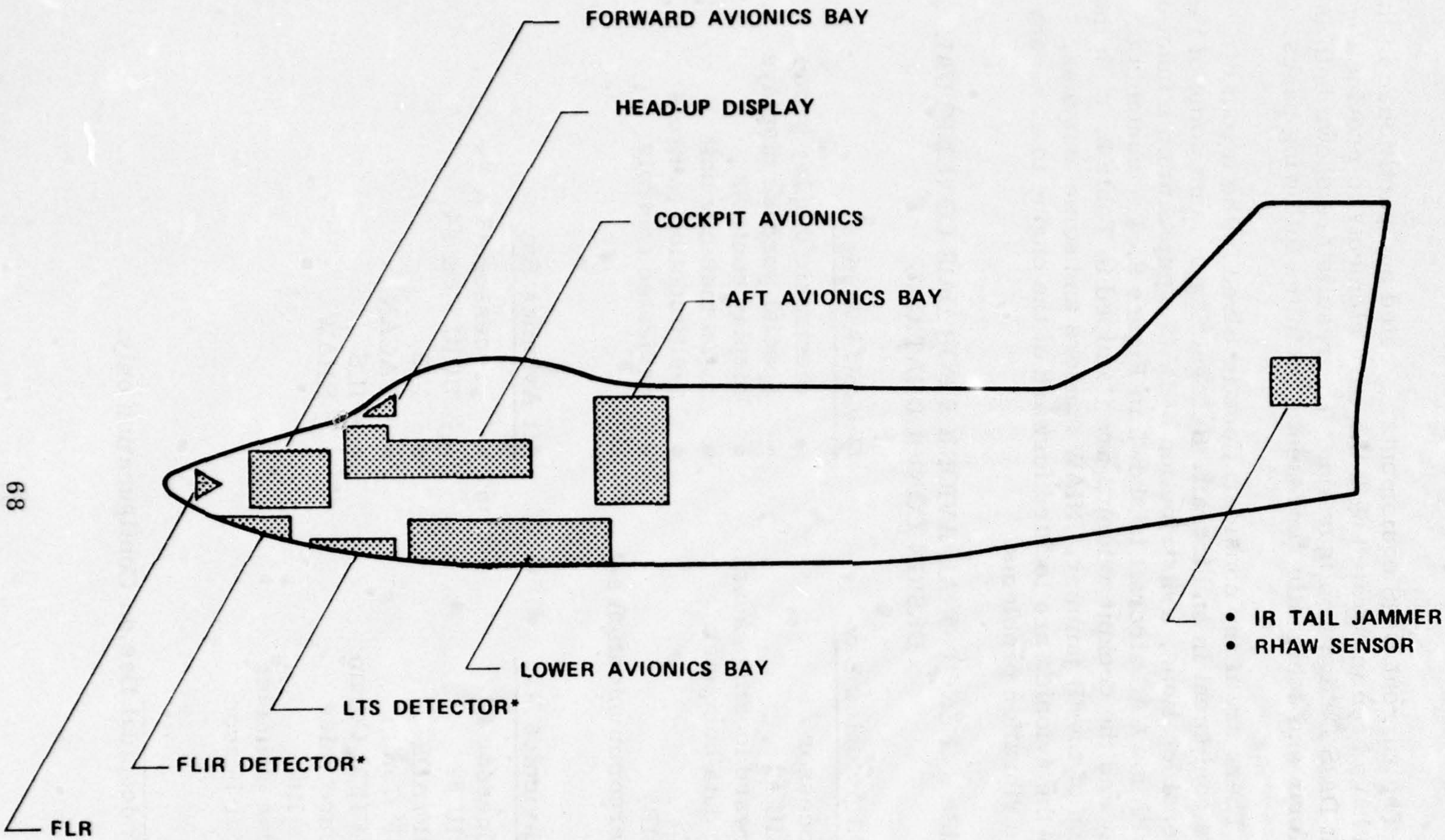
<u>Lower Avionics Bay</u>

- processor #2
- BCIU #2
- UHF/ADF
- UHF Comm
- VHF/FM Comm
- secure voice
- data link
- radar altimeter
- radar beacon

<u>Aft Avionics Bay</u>

- processor #3 & #4
- BCIU #3 & #4
- INS
- TACAN
- ILS
- RHAW

*1985 Conceptual Design Configuration only.



*1985 Conceptual Design Configuration Only

Figure 9 FUNCTIONAL AVIONICS DISTRIBUTION FOR DAIS CONCEPTUAL DESIGN CONFIGURATIONS

Three equipment bays, each containing DAIS core and sensor elements, are shown surrounding the cockpit. The forward and lower bays accommodate those sensors which must be directed forward without any obstructions (i.e., forward looking radar (FLR), forward looking infrared (FLIR), and laser target seeker (LTS). The absence of engine inlet ducts underneath the fuselage facilitates the placement of the FLIR and LTS housings. Some communication equipment, for which a minimum distance between antenna and receiver is preferred, is also contained in the lower bay. The cockpit avionics area contains all the control and display equipment.

The configuration depicted in Figure 10 represents the relationship between the sensors, multiplex core element, the processors, and the control and displays. Bus control interface units (BCIU) provide the interface control and data transfer function required to connect the various processors with the dual redundant multiplex lines. A single BCIU is needed to connect one processor with the multiplex line. Remote terminal units (RTU) interface the various subsystem sensors and controls and displays to the other DAIS core elements. As is shown, the BCIUs, RTUs and twisted shielded multiplex lines comprise the multiplex core element.

The arrangement shown depicts the probable number of RTUs. This is based on the signal handling capabilities anticipated in the design. Two RTUs are dedicated specifically to control and display elements to interface sensor data from the processors with the various controls and displays. All signals from the processors to the control and display RTUs are redundant to that failure of one RTU will not cause a loss of display functions.

A design goal for the DAIS C/D function is to achieve maximum flexibility and interchangeability. This would mandate the use of multipurpose displays exclusively. However, limitations in the area of display generation technology require that the current design use certain dedicated displays currently in inventory such as the AVQ-7 HUD, the AQU-6/A HSI, and the use of an ARU-21/A ADI instead of a VSI.

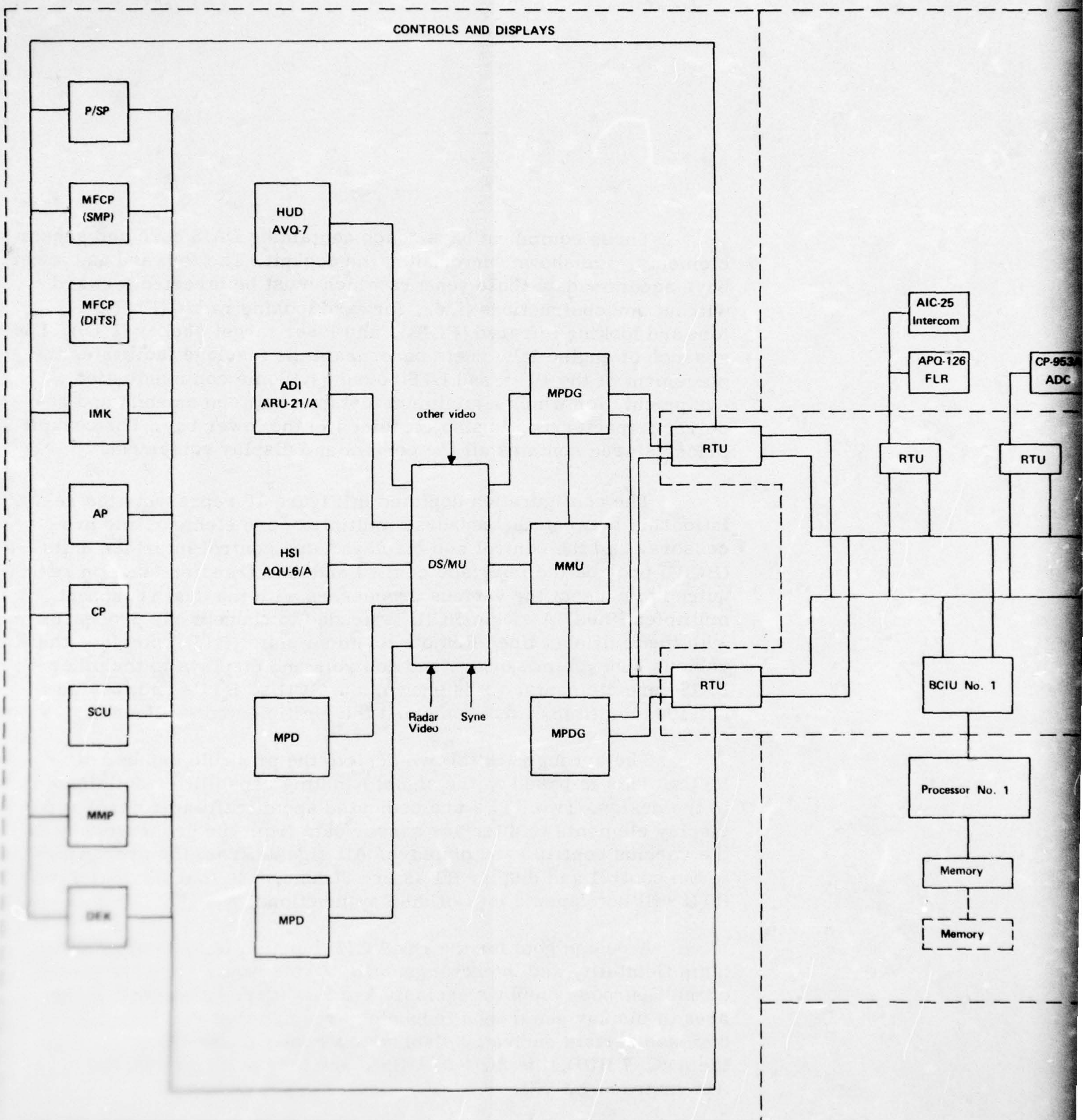
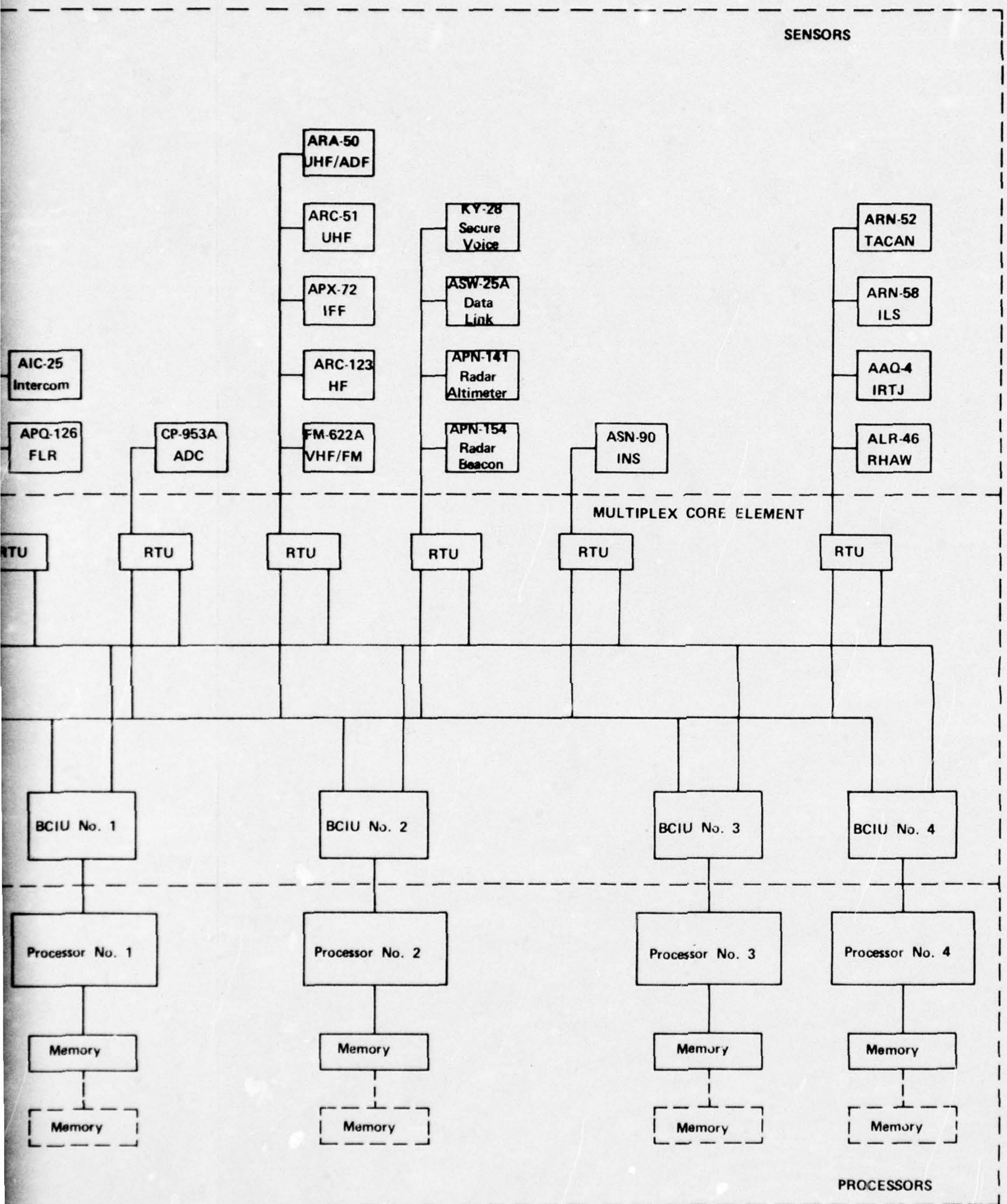


Figure 10 CURRENT DAIS CAS DESIGN CONFIGURATION



CONFIGURATION

2

The equipments shown as "Sensors" in the figure represent those front-end equipments that interface with the DAIS processors. In addition, a set of equipments has been selected which interfaces via the multiplex bus (through additional RTUs) with the Controls and Displays without having an interface with the processors. These are listed in Table 9.

Table 9 INTERFACING ELEMENTS - CURRENT SYSTEM CONFIGURATION

Equipment	Nomenclature	Source Aircraft
ECM	ALQ-119	A-7D
Chaff and IR Flares	ALE-38	A-10A
Camera	KB-18A	A-7D
Missile Launcher	LAU-88/A	A-10A
Gun	GAU-8/A	A-10A
Missile	AGM-65A	A-10A
AFCS	ASW-30	A-7D

SUMMARY

This section described the development of a "current" DAIS-configured CAS conceptual design configuration. In each functional area, the various types of equipments were first examined for selection. From the selected types, specific subsystems were chosen. Each subsystem was then examined at the SRU subassembly level and partitioned according to the DAIS concept, into sensor, computer, control/display. Power supplies were identified for eventual incorporation in a central power bus. The resulting components were then re-assembled into a "current" conceptual design configuration which, in the subsequent section, serves as the reference for development of a Mid-1980s conceptual design.

V. 1980 DAIS TECHNOLOGY PROJECTION AND EQUIPMENT SELECTION/PARTITIONING

SCOPE

This section discusses the technological advances in avionics which are expected to be available for a mid-1980s CAS aircraft. In addition the functions selected for the mid-1980s and specific equipments to perform those functions are included. Each of the selected equipments has been partitioned and a summary of this partitioning is also included in this section.

CONSTRAINTS

For purposes of this study, availability is defined by the proviso that a candidate subsystem will be fully developed and ready for operational implementation by 1985. It may well be that certain subsystems which are included in the 1980s DAIS Conceptual Design Configuration will be similar or essentially the same as subsystems in use on aircraft currently in inventory or in advanced development, e.g., A-10A, F-15A and F-16A. This is due to the fact that equipments requiring extensive laboratory effort, or which cannot be expected to be developed without a technological breakthrough, will not be considered. They fail to meet the previously stated requirement to be considered available for this portion of the study. Should such technological breakthroughs or other significant decreases in development time occur, the desirability of equipments so affected could be evaluated by exercising the LCC model at the appropriate time.

APPROACH

In order to determine realistic aircraft development-cycle times for the mid-1980s CAS aircraft, several fighter aircraft development programs were surveyed. These cycle times were applied to the equipment selection constraints of this study; i.e., equipment that can be operational (deployed) in 1985. The F-16 program was selected as being representative of both the current aircraft procurement philosophy and complexity of design and development. The first operational F-16 wing is, as nearly as can be ascertained, scheduled for activation in 1981. The first prototype was started in early 1973. This eight-year cycle time from the start of manufacture of a prototype aircraft to first deployment is typical.

It is expected, however, that major changes to the avionics suite could be implemented up to six years prior to the first deployment without severe impact on cost and schedule. Obviously, minor changes such as substitutions in individual subsystems, could be implemented further along in the development cycle.

Projecting these development cycle times to the January 1985 deployment date allows us to establish definite limits for the date by which development of the avionics must be completed. Therefore, for the purposes of this study, only avionics which can reasonably be expected to have been developed by the end of 1978 (six years prior to first deployment) will be discussed relative to anticipated advances and, in turn, be considered candidates for the 1980s conceptual design.

1980 DAIS CAS FUNCTION SELECTION

The technological developments anticipated by the mid-1980s time span detailed in this section are not in the direction of major functional changes. Review of the CAS mission described in Section II leads one to believe that, unless there is a major change or breakthrough in air-to-ground combat support, there will be no need for extensive changes in the equipment functions over those used in the current DAIS conceptual design configuration.

There are, however, some changes which are discussed in the following paragraphs.

Selection Rationale for New Functions

Probably the largest single problem associated with current CAS aircraft is that of target identification and location. Because of the current experience in this area, extensive efforts are being pursued and technological advances are occurring. Two systems, which are beneficiaries of such effort are laser target seekers (LTS) and forward looking infrared (FLIR); these have been selected for the mid-1980s CAS aircraft.

The LTS searches for a laser designated ground target. Upon acquisition of a target, the LTS tracks it so that the gimbal tracking rates may be used to derive range to and altitude above the target.

The FLIR develops a high resolution rectilinear map of the infrared characteristics of the terrain. This map, once developed, is presented either as an image on a cathode ray tube (CRT) or is recorded on film for site/target location and identification.

Exclusion Rationale for Mid-1980s Functions

Many of the functions excluded from the current DAIS design configuration, such as the LORAN, HARS, and Doppler, remain excluded from the mid-1980s design for the same reasons described in Section IV. The ILLLTV, which was excluded from the current configuration because of development status, has also been excluded from the mid-1980s configuration. The reason for exclusion from the 1980's design, however, is that its basic function, pictorial presentation of the terrain/targets, can be done under a wider range of combat and weather conditions by a FLIR, examples being haze, smoke and cloud layers.

Angle rate bombing systems (ARBS), which will be available by the mid-1980s time frame, were also considered. Although an ARBS is applicable to a CAS aircraft which is not extensively equipped with advanced avionics hardware, it has been excluded here because its basic functions are being accomplished by the FLR, IMS and core processors.

The other functions selected for the mid-1980s CAS aircraft are identical to those in the current CAS aircraft and are thus described in Section IV.

ANTICIPATED TECHNOLOGY ADVANCES & EQUIPMENT SELECTION

The following paragraphs briefly describe the technological advances in hardware development which will affect the avionics equipment selection for the 1980s DAIS conceptual design. Selected avionics subassemblies are discussed within the appropriate functional area, either navigation, communication, countermeasures, air-ground attack or control/display. A summary of those advances expected to be available in time for the Mid-1980s DAIS Conceptual Design Configuration are shown in Table 10.

Navigation

Inertial Navigation

Many technological developments are currently in progress both in next generation of current equipment, and in new types of equipment. These include the following:

- ring laser gyro navigators
- strapdown inertial navigators
- improved gimballed systems

Table 10 TECHNOLOGY ADVANCES AVAILABLE FOR MID-1980s DAIS

Function	Equipment Type	Anticipated Advances
NAV	Inertial	Strapdown; improved gimballed systems
	ADC	Computations performed in processor
	TACAN, ILS, ADF	Weight, size, power consumption
	GPS, OMEGA	Will become operational
	Hybrids	GPS/inertial available
COM		MSI, LSI; Shared Antennas; Modulation techniques
	JTIDS	Will become operational
	IFF	Improved performance, cost reductions
ECM		Power management
Air Ground Attack	Lasers	Laser target seekers will become operational
	FLIR	Reduced costs, weight size; improved display
	FLR	Improved performance, reliability

Table 10 (continued)

Function	Equipment Type	Anticipated Advances
C/D	Controls & Displays	Current displays and controls will be replaced by computer-driven MPDs plus IMFKs
Processing	Processors	LSI technology and microprocessors with large central processing capability
		BITE contained within microprocessors
		MOS (metal oxide semiconductors) Bipolar Schottky transistor-transistor logic
Power Supply		Central power supply core element
Interface Equipment	BCIU, RTU	Integrated within sensor or processor

Ring laser gyro navigators require significant advanced in technology to meet the availability constraints. Another limiting factor is the size of systems developed thus far. This type of system is, therefore, not considered as a viable candidate for the mid-1980s DAIS.

Strapdown inertial systems are considered to be active candidates for the mid-1980s aircraft. Current experience with strapdown systems is, however, largely limited to the laboratory environment; further disadvantages to be overcome are their expected accuracy and high cost.

The next generation of gimballed inertial navigation systems also provides candidates for mid-1980s DAIS. These systems, using improved platforms with dry or floated gyros, can be expected to show significant improvements in size, weight, and reliability while performing akin to current equipment. It is expected that, given the current emphasis on reliability improvements warranties (RIW), failure free warranties (FFW), etc., the LCC of these systems will be enhanced.

The selected INS is the ASN-109, an advanced gimballed platform in use on the F-15A; it is representative of the type of equipment expected in inventory during the mid-1980s. A backup example would be the advanced gimballed platform currently being prototyped for the F-16A.

Air Data Computer (ADC)

It is of little value to project advances for the ADC as a discrete subsystem for a DAIS-configured aircraft. The ADC's functions are almost exclusively computational and would be relegated to the processor with a dedicated interface to handle input signals from the associated sensors. The data computations would be transmitted to the using sensors or displays through the MUX bus. The selected unit is the ASK-6 from the F-15A; its capabilities do exceed somewhat those expected for a CAS aircraft in terms of functions and accuracies and therefore is considered more than adequate for this Mid-1980s DAIS Conceptual Design Configuration.

TACAN, ILS, and UHF/ADF

TACAN, ILS, and UHF/ADF can be grouped for purposes of discussing technological advances. All three equipments will see decreases in weight, volume, and power consumption with increases in acquisition cost to be offset by improved maintainability and reliability. The projected improvements will not adversely affect performance. It is also expected that these equipments will participate in antenna sharing with the communication subsystems.

The selected equipments are, respectively, the RT-1045/ARN TACAN, The R-1755/ARN ILS, and the OA-8639/ARD UHF-ADF. These are all from the F-15A and are representative of the next generation of "com-nav" technology.

Satellite Navigation

Current planning, if continued, will result in the implementation of a satellite navigation capability such as the Global Positioning System (GPS). The overall system is already well defined and a decision of the satellite configuration is expected within the next 12 months. The system, as presently planned, will use 24 satellites and will operate in the UHF band.

Depending upon the actual configuration selected and the consequent capability provided by the system, it may be possible to replace other on-board radio navigation systems entirely. Example of this are TACAN, the UHF-ADF, and perhaps the ILS. It is anticipated that GPS equipment will be available and could be incorporated in the mid-1980s DAIS avionics suite. The exact configuration and interfaces must await further definition.

Communications

Expected advances in the communications area can best be dealt with by discussing innovations across all the functional areas to be used in the Mid-1980s DAIS Conceptual Design Configuration rather than by each separate function. The general trends in electronics will manifest themselves as airborne communications move from the tube and transistorized type equipments currently in inventory to transistorized plus integrated circuits and highly integrated circuit equipments which are just coming into use. Application of MSI and LSI will yield smaller, lighter, more reliable communication equipment which will be primarily digital and highly automated, using the DAIS processors for control, error detection, corrections, routing, and address processing.

It is expected that more physical integration of communications equipment, on a modular basis, with greater use of shared antennas, and extensive investigation into various modulation techniques within one frequency band will be increasingly in evidence. These and other developments in the areas of communications integration will result in the development of new integrated communications, navigation, identification (CNI) subsystems, the advantages of which are: decreased dependence on ground control, lessening of line-of-sight constraints for information exchange, mutual position status knowledge among many users, secure information flow, and increased resistance to interference and jamming. Digital communication for command and control in the mid-1980s will require interoperability between AWACS and DAIS-equipped CAS aircraft. Consequently, it is anticipated that some type of Joint Tactical Information Distribution System (JTIDS) equipment could be incorporated in the Mid-1980s DAIS Conceptual Design Configuration.

Again examining our candidates for those which would be representative and available in the proper time frame, the selected equipments are ARC-109 UHF radio, ARC-123 HF radio, FM-622A VHF-FM radio, TSEC/KY-28 secure voice, AIC-18 intercom, and ASW-25A data link. The UHF is used on the F-15A, the HF on the F-111A, and the VHF, secure voice, and intercom on the A-10A. The selected data link is used on the A-7E.

Identification Friend or Foe (IFF) Systems in current use are a combination of transistors and integrated circuits with excellent weight and volume characteristics. New IFFs being developed, and just coming into Air Force inventory, have achieved approximately the same weight and volume but have increased performance capabilities, such as signal sampling and prioritized response, at an increased acquisition cost. It is believed that further performance, size or weight improvements are unlikely but reduction in cost may be realized.

IFF will participate in any emerging communication integration including antenna and frequency band sharing. The selected IFF is the APX-101 which is used on both F-15A and A-10A.

Countermeasures

The electronic warfare (EW) area has a history of dynamic technology; it is expected that this rapid turnover in EW sensors will continue as new threats are encountered and the necessary defenses developed. It is almost impossible to predict, with any degree of certainty, which sensors will be developed over the near future. Furthermore, the direction that development of ECM sensors takes is, for the most part, not germane to the purposes of this study since ECM equipment will not be DAIS-partitioned. The primary reason remains that the computer processing requirements are quite dissimilar from those of the other avionics, so that a dedicated processor is required. Also, the other ECM equipments are, for the most part, sensors which interface only with the EW processor or EW control panels, not with other avionics.

One of several new developments coming in EW is that of integrated ECM resource management controls referred to as power management systems. In general, the power management system, based on a high speed digital computer, identifies and analyzes threat signals, prioritizes the threats, chooses the proper jammer, and selects the specific modes of operation and power levels to cope with the threats, and finally monitors the reactions of the threat radars to the selected jamming techniques. This approach to an integrated ECM system will increase effectiveness and decrease demands for pilot attention as well as allow increased flexibility in meeting threats by allowing automatic selection of specific sensors and software for expected threats for a specific mission. A by-product of this development will be a decrease in the ECM cockpit control/display units. Several new aircraft have such power management systems and it is expected that mid-1980s aircraft will utilize more sophisticated versions of these systems.

The ECM sensors selected, then, are the same group used in the current configuration.

Air-Ground Attack

Laser Target Seeker (or Laser Spot Seeker)

Laser target seekers (LTS) are just completing development and one, the AN/AAS-35, will be deployed in the near future. Current LTSs are modular, contained in a pod connecting to a unique aircraft interface unit, and have a cockpit-mounted dedicated control unit. The electronics in the LTS pod are currently analog. The Mid-1980s CAS aircraft will have a current generation LTS with possible reliability and maintainability refinements. For the purposes of this task, the AAS-35, which is used on the A-10A, has been selected for the mid-1980s configuration.

Forward Looking Infrared (FLIR)

Forward looking infrared (FLIR) provides excellent imagery at night or in fog or haze conditions at ranges of about ten miles after being cued by another sensor such as the radar. FLIRs in current use are larger and heavier than is desirable for our application. Future developments will be concentrated on reducing acquisition cost as well as size and weight. A modular concept is being employed; separating a FLIR into cooling, scanning, optical, and signal processing modules. This approach holds much promise in cost reduction and increased maintainability as well as enhancing potential interservice use via commonality of modules. Other areas of improvement will include less complex cooling methods which should have a significant cost impact. Also, improvements achieved in developing FLIR for remotely piloted vehicles (RPVs), such as the use of reflective rather than refractive optics (which is the key to an important decrease in size and weight with enhanced reliability and cost), will be applied to aircraft systems.

One area requiring development for the CAS aircraft application of FLIR is the pilot's ability to read the display. Thus far, FLIRs have been used on multi-seat aircraft and have been operated by personnel who are not responsible for aircraft control. The results of a portion of the Pave Tack program to modify their FLIR pod for the single-seat A-10A will have a significant bearing on the resolution of this problem.

A future application of FLIR will be its use as a target designator for IR guided weapons (either missiles or bombs). The selected FLIR is the AAS-28, an equipment currently under test on an A-7D.

Forward Looking Radar (FLR)

Improvements in forward looking radar (FLR) for the near future will primarily include increases in performance and reliability. Performance improvements will include: longer detection ranges and improved tracking of low altitude targets; better detection of moving ground targets in clutter; and multimode operation. An important aspect of FLR will be to cue FLIR and similar sensors to targets as they come within the range of these more limited sensors.

The F-16A FLR has been selected as most appropriate to the functional requirements of the mid-1980s CAS aircraft.

Control and Display

The advancing technology in avionics presents the aircraft crew with more information than ever before and more rapidly than it can be assimilated. Future aircraft will have fewer and different type displays to relieve pilot workload during critical stages of the mission. The large array of engine, hydraulic, and electrical displays will be replaced by monitor-type displays (also known as exception displays), driven by digital avionics from a DAIS processor. The digital avionics will monitor the systems and make routine decisions, advising the pilot of the results or presenting him with alternatives, via the monitor displays, as appropriate.

The future displays will also differ in form as well as number. The current set of CRTs, control panels, knobs and switches will be replaced with computer-driven multipurpose displays (MPDs) able to present both imagery and symbology, plus integrated multifunction keyboards (IMFKs). The implementation of this functional integration of controls and displays requires new technology since CRTs, the only proven technology that currently meets the requirements for speed, brightness, bandwidth, and flexibility, have several disadvantages. These are: size (too deep), relatively short life, high voltage requirement, field survivability, digital-to-analog conversion, and inherent off-axis geometric distortion. Several innovative flat plate displays are in development to fill the need for multipurpose displays. A new flat plate-type CRT is one such display but its primary drawback is the high voltage requirement. Light emitting diodes (LEDs) offer promise but have insufficient intensity for all cockpit conditions and are costly. Gas discharge (plasma) panels are another but also lack sufficient intensity. Light modulators such as liquid crystals and ferroelectric ceramic panels have too slow a response time and tend to be temperature sensitive. The most promising candidates for new MPDs are improved flat plate CRTs and, secondly, LEDs with improved intensity.

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MID-1980S DIGITAL AVIONICS INFORMATION SYSTEM CONCEPTUAL DESIGN--ETC(U)
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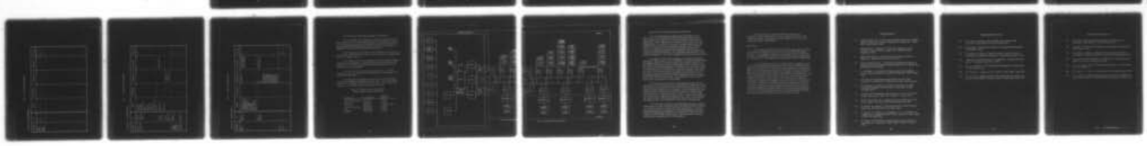

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The AVQ-20 Head-Up Display (HUD) from the F-15A has been selected due to its applicability and availability in the mid-1980s. An A-10A HSI and ADI have tentatively been included in the backup safety-of-flight instruments. The remaining selected elements are DAIS developmental items: the MPDs, IMFK, and MFCPs.

An independent map display set has been replaced, for the mid-1980s, by an electronic map display capability integrated within the DAIS Control and Display Subsystem.

A summary of the selected sensors for the mid-1980s DAIS CAS aircraft are segregated into functional groups and are listed in Table 11.

Projected Computer Technology

This section discusses advances in airborne avionics processors expected to be developed in the next several years such that they could be included in the Mid-1980s DAIS Conceptual Design Configuration. Advances are discussed in three areas: computer architecture, software development, and computer component technology.

Computer Architecture

A brief summary of the evolution of airborne computers is provided here to better illustrate the anticipated advances in the area of computer architecture for a mid-1980s CAS aircraft. Early airborne computer systems were a combination of analog computers and digital differential analyzers (DDA) with complex analog-to-digital converters. These processors were of unique design with inflexible, hard-wired logic and had complex interfaces which were prone to failure. A typical next generation processor system was based on a rigorously organized, highly integrated system using a large, general purpose, digital computer and a parallel DDA for real-time processing. The computation speed and complexity of the calculations to be performed, as well as the hardware available, necessitated selection of a large integrated system. This integrated system had disadvantages brought about by the highly integrated software required and the complexity of the central processor. The integrated software was extremely difficult to validate initially and had to be entirely revalidated after any changes. Furthermore, software changes involved redesign and extensive recoding after which processing could no longer be accomplished at the same iteration rate. The number and complexity of operating

Table 11 AVIONICS EQUIPMENT SELECTION

"1980s" CONCEPTUAL DESIGN FOR A CAS AIRCRAFT

Subsystem	Nomenclature	Aircraft
Function: NAVIGATION		
INS	ASN-109	F-15A
UHF-ADF	OA-8639/ARD	F-15A, A-10A
TACAN	RT-1045/ARN	F-15A
ILS	R-1755/ARN	F-15A
ADC	ASK-6	F-15
Beacon	UPN-25	A-10A
Radar Altimeter*	APN-194	A-7E, F-14A
Function: COMMUNICATIONS		
UHF	ARC-109	F-15A
HF	ARC-123	F-111A
VHF-FM	FM-622A	A-7D, A-10A
Secure Voice	TSEC/KY-28	F-15A, A-10A
Intercom	AIC-18	A-10A
Data Link	ASW-25A	A-7E
IFF	APX-101	A-10A, F-15A
Function: COUNTERMEASURES		
RHAW*	ALR-46	A-7D, F-4E
IR Tail Warning*	AAQ-4	RF-4C
Function: AIR-GROUND ATTACK		
LTS	AAS-35	A-10A
FLIR	AAS-28	A-7D (test)
FLR	APQ-( )	F-16A
Function: CONTROL & DISPLAY		
HUD	AVQ-20	F-15A
HSI	AQU-6/A	A-10A
ADI*	ARU-( )	A-10A
MPDs	**	**
IMFK	**	**
MFCPs	**	**

*Excluded from partitioning (Section VI)

**Not in "current" aircraft inventory but development is dictated via adoption of DAIS concept

modes caused problems with the integration of functions and the large number of sensors involved contributed to massive interface problems. All of the above led to high logistics support costs and unacceptable reliability and maintainability. The next advance in computer architecture attempted to improve on the integrated system concept by simplifying the computer system, i.e., distributing the central processor functions among separate computers organized by functions. This approach is conceptually quite similar to the current DAIS computer architecture although actual implementation has differed. An example of implementation of this architecture would be the Navy's F-14A which uses independent processors which were developed separately, each with its own software. Software validation and modification capabilities were enhanced and troubleshooting of the processor was simplified. The drawbacks of this approach are the very ones that the DAIS approach addresses. Each processor uses unique hardware and software which results in high logistics support costs and the need for many unique interfaces and all their attendant problems. Further, many hardware and software functions are duplicated within the separate processors which would be unnecessary in a more interactive system.

The next phase is currently being developed, and is implemented to some extent in the Air Force's F-15A. This new approach takes advantage of recent developments in large scale integration (LSI) technology and utilizes microprocessors with large central processing capability. A microprocessor module would be dedicated to a particular sensor. It would perform all of the sensor-oriented computations not dependent on information from other sensors. This would be done in parallel with, and independent of, both the central processor(s) and other sensor microprocessors. It is expected that a microprocessor module will be packaged as a one card subassembly in the sensor and, as such, would obviously have the same interface as the sensor. This approach precludes several of the major drawbacks of the distributed system: the modular microprocessors can be updated with minimum impact on other equipments; the interface problem is simplified; the central processor complex is simplified; duplication of hardware and software is minimized. Further advantages include the viability of the modular software approach with this concept, higher confidence built-in test (BIT) (see CITS Section V), and the inherent advantages of LSI circuitry: decreased size, weight, and power requirements with improved reliability and maintainability.

There should be LCC benefits employing the central processor/microprocessor concept. Although the acquisition cost of LSI chips is currently quite high, expanded use of these chips in industrial and commercial applications is expected to reduce that cost to a reasonable level.

Software Development

Software advances for the near future are expected to be in the nature of improvements and refinements to techniques in existence, rather than the development of new languages or approaches to software design. Software development will, obviously, be integrally related to computer architecture as described in the previous section. It is expected that the programming for each microprocessor module will be designed individually and that this software will be hardwired into the microprocessor memory. This method may be slightly wasteful in terms of fully utilizing the available computation capability in each microprocessor, however, the cost per LSI chip should be significantly less. The advantages of developing the software separately for each type of microprocessor module are evidenced in parallel design and development of software, simplified validation of microprocessor and central processor software, and increased maintainability in an operational environment.

The modular approach to software development holds considerable promise for controlling the historically troublesome areas of software design and validation. This concept calls for the functional division of the necessary software into specific modules under the control of an executive module. The modules can be designed and developed independently and then tested and validated in parallel with every other module. It also allows changes to be made to one module without impacting any other modules; new modules can be added and old ones deleted without impacting the whole system.

The future DAIS software will most likely be written in a high order language (HOL) to minimize software reliability problems and achieve maximum flexibility in design such that sensor reconfiguration is enhanced. HOL software in general, is not as efficient as assembler language in terms of memory utilization and execution time.

Another aspect of the future DAIS software, which is mandated by the multiprocessor configuration, is that the software will be asynchronous. Most conventional software is synchronous, that is, a specific time slot has been allocated for each task and all tasks are under the control of a system clock. The synchronous approach is not viable for a multiprocessor system which requires interaction among the processors. The LCC of asynchronous software should be acceptable in that the somewhat higher initial cost will be offset by savings in software validation.

Based upon the previously stated expectations regarding software development, the basic core processor requirements in terms of both memory capacity and operational speed are assumed to remain valid and reasonable for the mid-1980s time frame.

Computer Component Technology

Three semiconductor technologies are likely candidates for the avionics microprocessor chip set of 1985. These are metal oxide semiconductor (MOS), bipolar Schottky transistor-transistor logic (TTL), and the relatively new integrated injection logic (IIL). Of these, MOS has superiority in size and power requirements, while Schottky TTL has the edge in speed and environmental (high temperature and radiation) reliability. IIL is very new with little production experience and failure data. However, if it becomes a viable technology, it will offer all the good features of Schottky TTL with considerably lower power requirements.

Custom LSI would not appear to be a viable alternative to the microprocessor for the 1985 avionics computer due to its high cost in small lots, questionable reliability without a long term production base, and inflexibility to system modifications. Adoption of the DAIS concept, however, would create the large procurements necessary to alleviate many of these problems. Flexibility for system modification also rules against the programmable logic array (PLA) as a component. The read only memory (ROM) will do the same job less efficiently but allow simple system modification.

Power Supply

One of the concepts which might be explored further in the near future is that of a central power supply core element. Certain of the DAIS-configured system's advantages are derived from application of standardization and modularity which, it is believed, might be extended to consideration of subsystem power supplies. The opportunity exists to define "standard" types and quantities of power to be generated from a family of power supply units; these could then be distributed appropriately throughout the avionics system installation, each configured to support a specific group of functions or sensor subsystems by the choice of modules contained there. An additional capability could be developed by their being able to tie in among themselves to overcome a limited number of subassembly failures.

This step would first require further specification of the DAIS interface to potential sensor designers and their application to new hardware development activities.

CITS

In Section IV, the basic capabilities of a CITS, in terms of software sizing, were discussed briefly. It is believed that those functions, as listed, will remain unchanged. The physical distribution of the software modules and their capacity for fault isolation and detection, however, should be significantly different.

With the current DAIS design, CITS software is contained in one of the core element processors from which it must communicate through the MUX bus and interface units with all of the sensor subsystems. This particular software module is reasonably complex and includes functional operating mode priorities, troubleshooting sequences, as well as basic accounting for discrete fault and mode signals. The constraints upon its effectiveness derive from its being remote as well as the fact that it is intended to contain many varied troubleshooting capabilities.

For a mid-1980s conceptual design where microprocessors may be implemented as a part of each sensor subsystem, the opportunities for a greatly enhanced CITS effectiveness are readily apparent. The core element processor containing CITS software can have a much simplified problem to solve. Basically, its functions can be reduced to integrated operating mode priority decision making and accounting for fault indications; i.e., listing which LRUs should be removed at postflight maintenance. Beyond that, the core element software will also serve as an intermediary for initiating troubleshooting sequences which ought not to be automatic due to their degrading effect on weapon system operation.

The fault detection and isolation capabilities can now be packaged with the related sensors in such a manner that each troubleshooting module is confined to one sensor subsystem where its complexity is a function of that sensor designer's knowledge of required sequences. False or misleading failure indications will be less in evidence due to replacement of the lengthy interface sequences between core element and sensors as well as elimination of the inevitable tradeoffs for core element computer space performed by a third party not as competent in each sensor's requirements, obviously, as its designer.

It is believed that this modification to CITS implementation could be accommodated for the Mid-1980s DAIS Conceptual Design Configuration and is, therefore, included there.

Interface and Multiplex Data Bus

For the interface area, it is anticipated that the functional capabilities of the BCIU and RTU will be accommodated, to varying extents, within the particular processor or sensor, ranging from very little to fully integrated. The degree of such adaptation will depend more on economics and management preference than technological capability.

For the data bus, light interface technology was considered as a potential replacement for the current implementation. Capability for both noise rejection and wide bandwidth are definite advantages. To the contrary, however, present limitations on coupling (8 maximum for fiber optics versus 33 maximum for a MIL-STD-1553A bus) and the thermal constraints posed by the physics of diode materials make serious consideration for the mid-1980s inconsistent with the ground rules of this task. With those problems alleviated, the potential advantages of light interface technology will certainly merit re-evaluation at a later time.

Partitioning

Approach to and Exclusion from Partitioning

The approach to and the exclusions from partitioning are the same for the mid-1980 equipments as applied to the current equipments. Rather than reiterate that discussion, please refer to Section IV for partitioning approach and exclusions.

1980s CAS Avionics Partitioning

A summary of the selected Mid-1980 avionics suite, partitioned to the subassembly level, is contained in Table 12. This table is subdivided into the five functional groups: navigation, communication, countermeasures, air-ground attack, and control and display. Within each functional group, the specific equipments are subdivided by line replaceable units (LRUs). The functions of each subassembly have been partitioned as described in the previous paragraph. Table 12, "Mid-1980s Avionics Partitioning", also contains a catalog number (cat. no.) for each equipment, which provides a cross reference to the summary sheets (see description of backup data package in Section III) with further details on each equipment. Those equipments which have been excluded from partitioning have been included in the table for the sake of continuity and are designated "NA". As in Table 4, this tables does not include amounts, couplers, or antennas of a simplified nature, nor does it include any computer LRUs whose functions are entirely accommodated by the DAIS processor elements.

Table 12 MID-1980s AVIONICS PARTITIONING

FUNCTION GROUP NAVIGATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ASN-109 INS	CN-1376 IMU	PLATFORM MODULE ACCEL. (X,Y & Z) GYROS (X-Y & X-Z) SERVO ELEC. CONVERTER MOD.	INERTIAL COMP. MOD.		POWER SUPPLY MOD. BATTERY ASSY.	1.2.2
	C-8849 NCI			CONTROL/DISPLAY		
OA-8639/ARD UHF/ADF	AM-6440 ELECTRONIC CONTROL AMP.	CHASSIS INTERCONNECT RF SW. PREAMP. MOD. FILTER/DET. CARD	BIT CARD ANT. CONT. CARD HORIZ. SIT. IND. CARD CLOCK/COUNTER CARD		+5V POWER SUPPLY -5V POWER SUPPLY POWER INPUT MOD.	1.3.2
RT-1045/ARN TACAN	RT-1045 RADIO RECEIVER TRANSMITTER	POWER AMP. MOD. FREQ. GEN. DECODER CIRCULATOR - MONITOR SELF TEST RECEIVER	INTERNAL CONTROL BEARING COMPUTER RANGE COMPUTER DIGITAL INT.		POWER SUPPLY ISOLATOR	1.4.2
R-1755/ARN INSTRUMENT LANDING RECEIVER	R-1755 INSTRUMENT LANDING RECEIVER	GLIDESLOPE RF LOCALIZER RF FREQ. CONT./AUDIO MARKER BEACON REC. CHASSIS	GLIDESLOPE INSTRU. LOCALIZER INSTRU.		ELAPSED TIME IND. INV. POWER SUPPLY NO. 1 POWER SUPPLY NO. 2	1.5.2
ASK-6 AIR DATA COMPUTER	ASK-6 AIR DATA COMPUTER	TOTAL PRESS SENSOR STATIC PRESS SENSOR CHASSIS	PROGRAM MEMORY ARITH. CARD A ARITH. CARD B PROGRAM CNTL. TIMING CNTL. CENT. COMP. CNTL. CENT. COMP. SIG. COND. ANALOG OUTPUT DISCRETE OUTPUT PARALLEL/SERIAL CONV. FREQ./DIGITAL CONV. A/D CONV.		POWER SUPPLY	1.7.2

Table 12 MID-1980s AVIONICS PARTITIONING

FUNCTION GROUP NAVIGATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
UPN-25 RADAR BEACON	RT-855 RADIO RECEIVER TRANSMITTER	RF HEAD IF AMP. ENCODER MODULATOR			POWER SUPPLY	1.9.2
APN-194 RADAR ALTIMETER SET	NA					1.10.2

Table 12 MID-1980s AVIONICS PARTITIONING

FUNCTION GROUP COMMUNICATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ARC-109(V) UHF RADIO	RADIO RECEIVER TRANSMITTER RT-967	RF TRANSLATOR EXCITER MODULATOR FREQ. SYNTHESIZER IF/AUDIO AMP. GUARD RECEIVE MECHANICAL TUNER	BCD COMPARATOR		POWER AMP. POWER SUPPLY	2.1.2
	C-6364 & C-7425 RECEIVER - TRANSMITTER CONTROL			TUNING MODE SEL. PRESET CHAN. CONT. PRESENT FREQ. IND. MANUAL FREQ. SEL. MANUAL FREQ. IND. PRESET FREQ. CH. CONT. VOLUME SW. ASSY. TONE SW. ASSY. SQUELCH SW. ASSY.		
ARC-123 HF RADIO	RT822 RECEIVER- TRANSMITTER	WIDEBAND AMP. 1MHz FREQ. STD. FIXED FREQ. GEN. R-T LOCAL OSC. RF AMP. PARAMETRIC AMP. PUMP AMP. 124.7 MHz IF 700KHz IF AUDIO CARD			AUX. POWER SUPPLY	2.2.1
	AM-4573 AMPLIFIER- POWER SUPPLY	RF AMP. OUTPUT NETWORK AGC/ALC AMP. RF DRIVER BIAS/ALC PHASE DETECTOR LOGIC MODULE			POWER SUPPLY RELAY BOARD COMPONENT BOARD RECTIFIER BOARD	
	C-7073 RADIO SET CONTROL	VCO & BUFFERS LOOP 1 LOGIC LOOP 2 LOGIC REFERENCE GEN 1 RF MIXER			VOLTAGE REG.	

Table 12 MID-1980s AVIONICS PARTITIONING

FUNCTION GROUP COMMUNICATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
FM-622A RADIO SET VHF-FM	FM-622A RADIO SET REC. TRANSMITTER	VHF TUNER ASSY. RF OSC. ASSY. XTAL. REF. SYS. ASSY. IF AMP ASSY. RF CONT. ASSY. HOMER, DET. AMP ASSY. AUD. FREQ. AMP. ASSY. OSC. BUFFER ASSY. RF AMP. ASSY. ISOL. AMP. ASSY. AMP MOD. ASSY. REC. TRANS. CHASSIS GEARBOX ASSY. IF ATTENUATOR ASSY.			VOLT REG. ASSY. POWER SUPPLY ASSY.	2.3.1
	C-921/FM RADIO SET CONT			FREQ. SEL. & IND. MODE SELECTOR VOLUME CONTROL SQUELCH SWITCH		
TSEC/KY-28 SECURE VOICE	NA					2.5.1
AIC-18 INTERCOMMUN- ICATIONS SET	AM-1963 AMPLIFIER ASSY.	A-F AMP. A-F AMP. RELAY RELAY SOCKET TERMINAL BOARD		OUTPUT LEVEL/SEL.		2.6.2
	C-2323 OR C-3943 MONITOR PANEL			PANEL LAMP PANEL LAMP MONITOR SWITCH		
	C-2106 OR C-3942 INTERCOM SET CONTROL	A-F AMP. A-F AMP. RELAY RELAY SOCKET TERMINAL BOARD TERMINAL BOARD		CALL SWITCH VOLUME CNTL. SELECTOR SWITCH		

Table 12 MID-1980s AVIONICS PARTITIONING

FUNCTION GROUP COMMUNICATION

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
AIC-18 INTERCOMMUNICATIONS SET	C-2105 INTERCOM STATION	A-F AMP. A-F AMP. RELAY RELAY SOCKET TERMINAL BOARD		CALL SWITCH VOLUME CONTROL		2.6.2 (Cont)
ASW-25A DIGITAL DATA COMMUNICATION SET	CV-2230A CONVERTER RECEIVER	SYNTHESIZER RECEIVER	DC/DC CONVERTER REGULATOR DRIVERS & DISC. LOGIC DC/DAC & DATA RECONST DC/DAC & 320KHz OSC. LOGIC & DATA STORAGE			2.7.1
	C-7100 CONTROL PANEL			CONTROL PANEL		
APX-101 IFF	RT-1063B RECEIVER-TRANSMITTER	RCVR-XMTR ASSY PULSE WIDTH DIS. SUPPRESSOR VIDEO PROCESSOR EVAL./	CODER A & B CODER C & D CLOCK AND COMMUTATOF DECODER AUTO. OVERLOAD CONT. MODE 4 INTERFACE MODE 4 CONTROL BIT STIMULATOR BIT EVALUATOR		POWER SUPPLY	6.1.2
	KIT-1A/TSEC MARK XII COMPUTER	MARK XII COMPUTER				
	IFF EMERG. SWITCH			IFF EMERGENCY SWITCH		
	C-6280P TRANSPONDER UNIT			TRANSPONDER CONTROL UNIT		
	IFF CONTROL PANEL			IFF CONTROL PANEL		

Table 12 MID-1980s AVIONICS PARTITIONING

FUNCTION GROUP COUNTERMEASURES

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
ALR-46 RHAW	NA					3.1.1
AAQ-4 IR TAIL WARNING	NA					3.2.1

Table 12 MID-1980s AVIONICS PARTITIONING

FUNCTION GROUP AIR-GROUND ATTACK

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
AAS-35 LASER TARGET IDENTIFICATION SET	DETECTOR LASER ILLUMINATION TARGET	DOME ASSY. ROLL GIMBAL PITCH GIMBAL RECEIVER/SENSOR OPTICS DETECTOR AMPLIFIERS CONTROL ELEC. VOLTAGE REG. DC-DC CONV. 2 BORESIGHT RESOLV. DRIVE AMPS.				4.2.1
	CONTROL DETECTOR ADAPTER	POD INPUT RECVR. OUTPUT DRIVES BITE MODE CONTROL			POWER CONVERSION	
	LASER CONTROL TARGET IDENT. SET			SWITCH & INDIC. STATUS LIGHTS ELECTRONIC CKTS.		
AAS-28 FORWARD LOOKING INFRARED DETECTING SET (FLIR)	DETAIL DATA PENDING					4.3.2
FORWARD LOOKING RADAR (FLR) (F-16)	DETAIL DATA PENDING					

Table 12 MID-1980s AVIONICS PARTITIONING

FUNCTION GROUP CONTROL/DISPLAY

EQUIPMENT	LRU	SENSOR	PROCESSOR/MUX	CONTROL/DISPLAY	POWER SUPPLY	CAT. NO.
AVQ-20 HUD	IP-1103 DISPLAY UNIT	LIN. CORR. AUTO. BRIGHTNESS CONT. STANDBY RET. & BIT CONT. BORESIGHT CORR. DEFLECTION AMP. CONT. BORESIGHT CORR. CBC Y SENSOR CBC X SENSOR ABC SENSOR AMB. LIGHT SENSOR COOLING FANS CAMERA RELAY ASSY.		CONTROL PANEL	STANDBY POWER SUPPLY LOW VOLT. POWER SUP. HIGH VOLT. POWER SUP.	5.1.3
	CP-1111 SIGNAL DATA PROCESSOR			I/O I/O I/O I/O DATA MEMORY PROGRAM MEMORY DATA PROCESSOR DATA PROCESSOR DATA PROCESSOR DATA PROCESSOR WAVEFORM GEN. WAVEFORM GEN. WAVEFORM GEN. WAVEFORM GEN. WAVEFORM GEN. MOTHER BOARD	POWER FILTER LOW VOLT. POWER SUP.	
AQU-6/A HSI	NA					5.2.1
ADI (A-10)	NA					5.4.2

Mid-1980s DAIS Conceptual Design Configurations

The mid-1980s DAIS equipments selected and partitioned in this section have been integrated, using the core elements detailed in the backup data package to complete the Mid-1980s DAIS Conceptual Design Configuration illustrated in Figure 11. The layout of equipment in the aircraft is that shown in Figure 9.

The relationship of the BCIUs and the RTUs remains the same as in Figure 10 which conveyed the necessary interface relationships with the multiplex data bus.

The displays have been modified to show the head-up display, vertical situation display, and horizontal situation display as data outputs from the display switch/memory units which are used to drive the CRT-type displays.

Two new subsystems have been added to the mid-1980s design and these are indicated by the dashed lines around the LTS and FLIR subsystems.

Certain selected equipments interface only with the DAIS Controls and Displays through a separate RTU. Since these equipments do not interface with the processors they are not shown in Figure 11. These equipments are listed in Table 13.

Table 13 INTERFACING ELEMENTS - 1980s SYSTEM CONFIGURATION

Equipment	Nomenclature	Source Aircraft
Chaff & IR Flares	ALE-38	A-10A
ECM Pod	ALQ-119	A-10A
Camera	KB-27A	A-10A, F-15A
Missile Launcher	LAU-88A	A-10A
Gun	GAU-8/A	A-10A
Missile	AGM-65A	A-10A

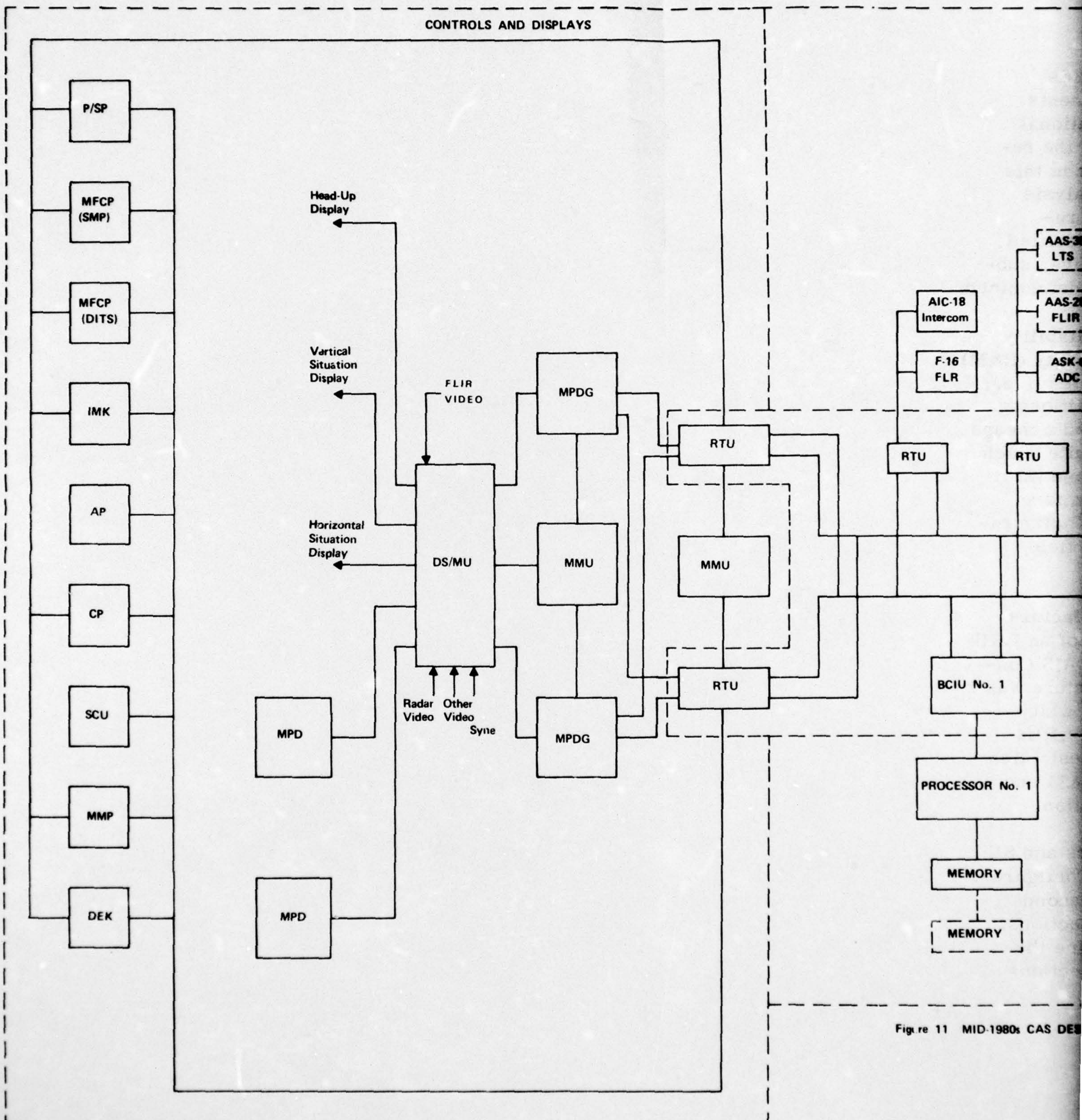

Figure 11 MID-1980s CAS DES

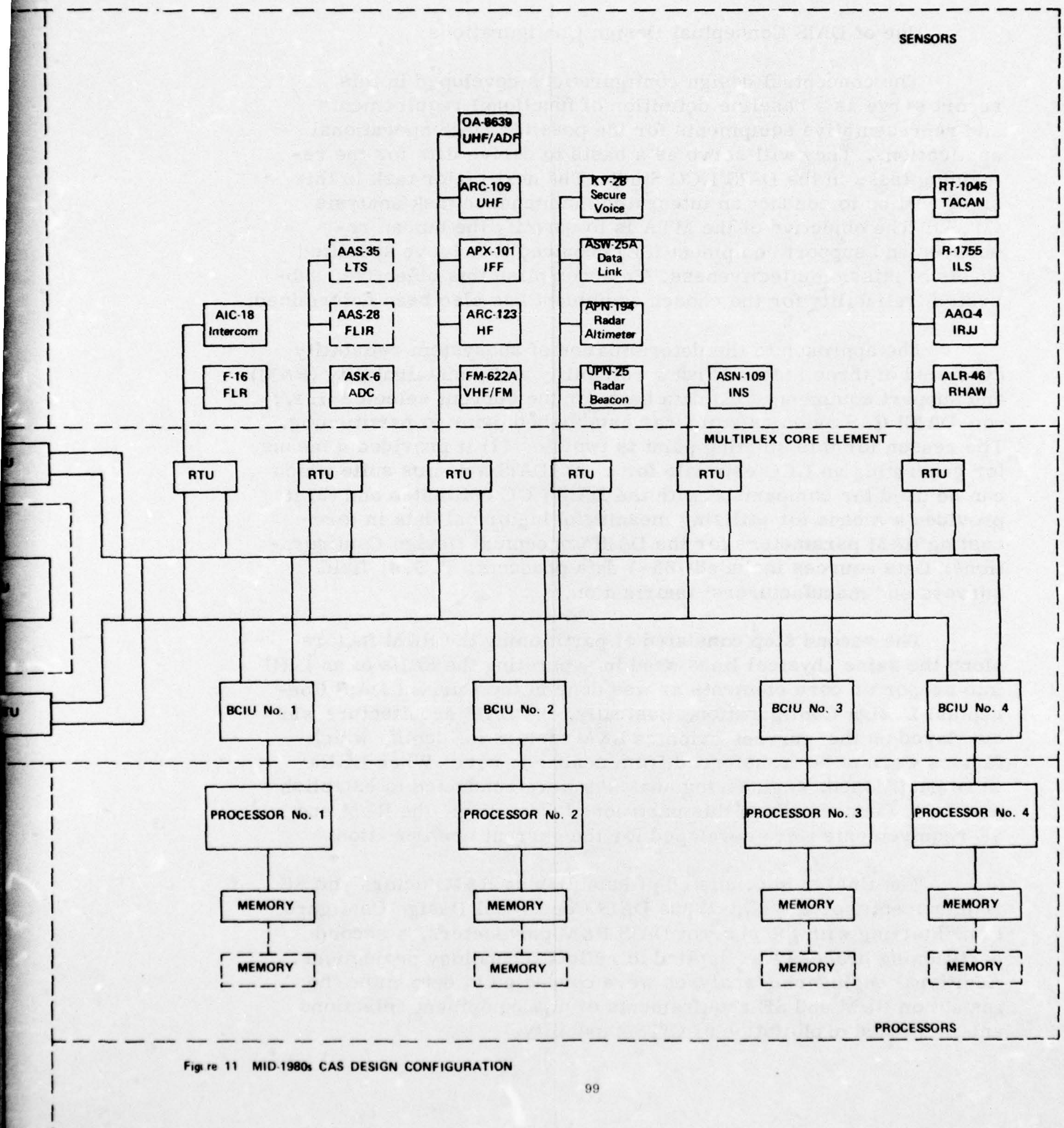

Figure 11 MID-1980s CAS DESIGN CONFIGURATION

Use of DAIS Conceptual Design Configurations

The conceptual design configurations developed in this report serve as a baseline definition of functional requirements and representative equipments for the possible DAIS operational applications. They will serve as a basis to derive data for the remaining tasks in the DAIS LCC Study. The next major task in this study will be to conduct an integrated maintenance task analysis (MTA). The objective of the MTA is to quantify the human resources and support equipment (SE) required to achieve specified levels of mission effectiveness. To accomplish this objective, subsystem reliability for the chosen equipment has also been determined.

The approach to the determination of subsystem reliability consisted of three steps. First a reliability and maintainability (R&M) and support equipment (SE) data bank for the current selected (i.e., non-DAIS) CAS avionics suite was established prior to partitioning. The reason for this starting point is twofold: (1) it provided a means for generating an LCC estimate for a non-DAIS avionics suite which can be used for comparison with the DAIS LCC estimates and (2) it provided a means for utilizing meaningful historical data in forecasting R&M parameters for the DAIS Conceptual Design Configurations. Data sources included: 66-1 data products, T.O.s, field surveys and manufacturers' information.

The second step consisted of partitioning the R&M factors along the same physical lines used in separating the SRUs of an LRU into sensor or core elements as was done in the Current DAIS Conceptual Design Configuration. Basically, the DAIS architecture was overlayed on the current avionics R&M factors to identify which factors were to be transferred from sensor to core. When LRUs were partitioned, engineering analyses were conducted to establish new R&M factors. Using this partitioned data, then, the R&M and SE requirements were developed for the current configuration.

The final step consisted of establishing R&M factors and SE requirements for the Mid-1980s DAIS Conceptual Design Configuration. Starting with the current DAIS R&M parameters, a second partitioning process was applied to reflect technology projections. Additional engineering analyses were conducted to determine the impact on R&M and SE requirements of new equipment selections and increased exploitation of CITS capability.

Results of the R&M analyses will be included in the computerized data banks (future contract deliverables) which will contain the results of maintenance task analyses on the two DAIS conceptual design configurations.

SUMMARY

This section first described the direction and apparent trends in advancing technology for each of the major avionics functional divisions. The anticipated changes were set against their estimated schedule of availability in order to define those advances which could be considered for a Mid-1980s DAIS Conceptual Design Configuration.

In each functional area, the relevant types of equipment were examined for selection or exclusion and then, for the selected types, specific subsystems were chosen from those expected in inventory in 1985. Each subsystem was examined at the SRU level and partitioned appropriately to the DAIS concept. The resulting components were then re-assembled into a composite mid-1980s conceptual design. The design configuration is specified in sufficient detail to support subsequent maintenance task analyses, the development of realistic acquisition, operation and support costs, as well as the development of suitable maintenance manpower training techniques and criteria. The avionics subsystems were treated as modules in order that the resulting configuration would facilitate the performance of tradeoff analyses during the conceptual phase of the systems acquisition process. The LCC modeling system which is the final product of DAIS LCC Study will be the vehicle for such tradeoff analyses.

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